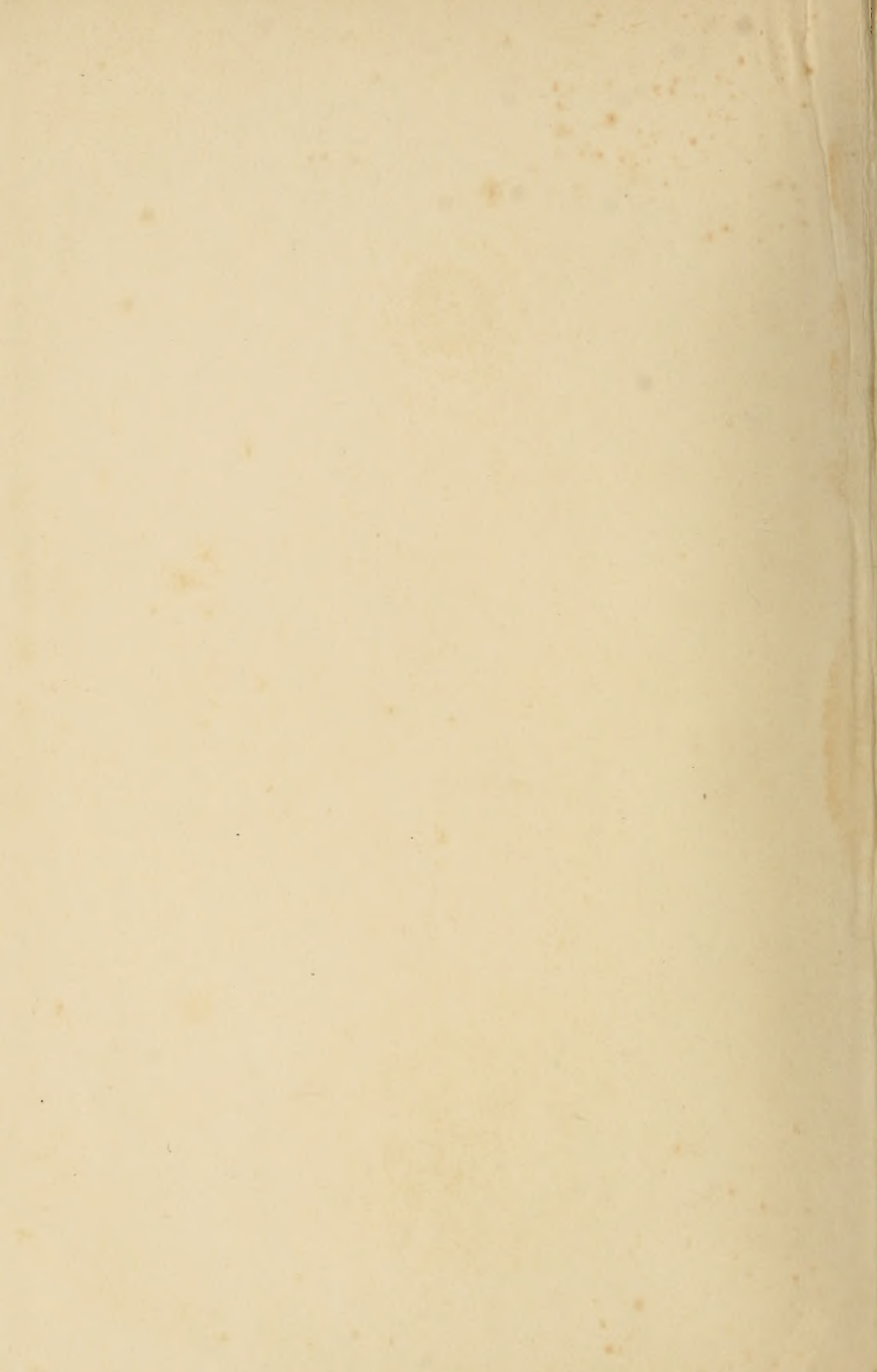




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Yours faithfully
A. D. Little

Chemical Engineering Progress

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TRANSACTIONS OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

THE HUMAN ELEMENT IN THE MILL

By HUGH KELSEA MOORE

Paper Read and Discussed at the Gorham and Berlin Meeting.

Gentlemen:

Your secretary has asked me to write a few introductory remarks concerning the mills of the Brown Company located in Berlin, N. H., and I have chosen as my subject "The Human Element in the Mill." In order that these remarks may be clear, it will be understood that the Brown Company is a consolidation of two distinct companies which were under two distinct systems of management. One has always been under the Brown management. As it would take too much space to go into the separate activities of each, and as it is not my object to write a history but to lay down certain principles and show how they are applied, I am writing of the Company as if it had always existed as one organized entirety instead of two separate institutions. However, it must be borne in mind that the unfavorable facts herein mentioned took place in one of our mills before it came under the Brown management. In writing this paper certain things do not appear in plain English, and for the true meaning of a part of my message one will have to read between the lines correlating the principles with the facts laid down. I have arranged this paper in regard to sequence of principles, and consequently, the facts are not arranged in accordance with sequence of events. The charts submitted are illustrative of principles, and if they contain any other information such information is of only secondary importance. Lest I become tedious I shall confine myself to one illustration of each principle.

Undoubtedly the most important factor in the development and operation of a mill is the human element. In this mill we have thirty-six nationalities and I do not know how many religions. We have Republicans, Democrats, Socialists, Prohibitionists. We

have here a heterogeneous mass of humanity, having different customs and ideals. The trend of thought of one man is diametrically opposite to that of his neighbor. The outlook upon life and society of one group is so far different from that of another group that it may seem at first sight that one has nothing in common with another. We have men in the mill who claim that inasmuch as the mill could not run without the employment of labor that labor is entitled to all the income of the mill and do not recognize the rights of capital at all. We have men who wish to set an arbitrary scale of wages irrespective of the producing capacity of the individual, not realizing that such a policy tends to bring everybody following the same to a dead level and tends to check his personal development. Many would like the continual shortening of the day with increased wages, irrespective of whether they do a day's work or not, and hardly a man recognizes the fundamental fact that money which comes too easy is one of the worst evils which can be wished on him, leading him and his family into habits of extravagance and laziness which totally unfits him for his job or for meeting adversities which sooner or later overtake every man. We have in our records data which are not worth the paper they are written on. We have seen the time when six men had the will and the power to shut down a whole mill. We have seen the time when thievery was the custom, where hiding and sleeping in the secluded places of the mill was the style. We have seen the time when millwrights would sneak out of one mill unseen, stay a few hours at home, sneak in and be counted as present by their foreman when time for dismissal came. All these things as above stated were considered privileges, so much so that when a fence was put around the mill to check some of this, the men aggrieved went out on a strike on account of the curtailment of their fancied privileges and the others not affected by the putting up of the fence went out on a sympathetic strike. It may be they saw the hand-writing on the wall and also feared the abridgment of their fancied privileges. I might continue in this strain, but why heap on the agony? It is not my intention to catalogue these evils, but to show that right here in Berlin we have had all the ailments with which large industrial plants all over the country have to contend. What was the cause of all these evils? Was it due to real grievances or fancied grievances? (I mention these together because the psychological effect on the man is the same in either case.) Was it due to ignorance or incompetence? Were

the men wholly to blame, or might not a share of this condition be laid on the management? Might not the trouble be due to absentee management and favoritism? How much of this was due to misunderstanding? How much of this was due to antagonisms arising out of the mutual knowledge that employer and employee are not in sympathy with each other?

If you go into this mill today you will find the men happy and contented, honest and capable, wiser and more tractable. You will find them workers instead of slackers. What a tremendous change and practically all of it dates to the time they came under the Brown management.

Before going into the subject as to how these changes were brought about it is necessary to find out what caused these evils, for, if we know the cause, it is possible, even probable, that we may devise the remedy by the simple removal as far as possible of the cause. A mill or a community may be compared to the human being. It is made up of many parts, the functioning of which vary in both manner and degree.

With the human machine the well-ordered and well-nourished mind and the well-ordered and the well-nourished body are the greatest safeguard against disease and infection. Some germs which may be powerless in a healthy body may cause death in an anaemic one. On the other hand there are germs which, introduced into any human machine no matter how well nourished, are almost certain to spread and cause trouble.

The mill is subject to diseases and infections in much the same manner as the human machine and eternal vigilance is the price of keeping the mill in a healthy condition.

Right here I want to mention one of the conditions which may or may not be bad but which has therein a latent power for evil and may develop into a malignant cancer. I refer to absentee management. When the management lives in the vicinity of his workers he is in touch more or less with the changing conditions in the community and he may grow with the community. He can have much the same relation to his employees or the community as the doctor may have with his patient, as the lawyer may have with his client and the pastor with his flock. If a doctor has a case of blood poisoning he operates before it can spread and permeate the whole of the patient's system. In the same manner resident management may operate and remove the infection before it has a chance

to spread. I have known doctors who cured their patients by administering bread pills because the patient imagined he or she was sick. In the same way the management who lives in touch with his employees may cure a fancied grievance by removing the misunderstandings. On the other hand with absentee management the doctor, so to speak, is relying on reports of his superintendent which may or may not contain a good diagnosis of the case. They may be and in all probability will be more highly colored in regard to matters in which he is personally interested. The manager, even though he may try his best to do the proper thing, is handicapped by lack of complete knowledge. On the other hand on account of his being out of constant touch with the sentiment of the community, the flame of sympathy which is constantly fed and fanned by the intimate contact with his fellow men who are also his employees dwindles down for lack of fuel, becomes a spark and finally dies for lack of nourishment. Taken as a class the workmen are more sympathetic than are their so-called social superiors. When these social superiors tear up the roots that furnish them this most beneficent nourishment and plant them in the cities where graft, avarice and greed are the main components of their business relations and artificiality of form and ceremony rather than sincerity and simplicity are the main components of his relaxations in so-called society, then the natural result must inevitably follow. In order to exist he must adjust himself to his new environment.

Dr. Morton Prince believes he has shown that a personality can be split up into other personalities less complete and that these products of cleavage can be still further dissociated. There seems to be no limit to the number of these subdivisions. He points out that the subsequent subdivisions take place with much greater ease than the first cleavage. He also produces a cure on the hypothesis that the true personality is that one which can most readily adjust itself to changing conditions. I am not prepared to affirm or deny his conclusions as regards a personality, but I do believe that if the words, "Mill organization" were substituted for personality that the remark would be absolutely true.

Here in absentee management the first rift may occur in the mill community as an organized entirety. The management and employees become out of sympathy one with the other and the former organized entirety becomes to this extent dissociated. Now without going into other causes producing the first cleavage let us recog-

nize a weakened condition of our former organization. We now have a plant in which misunderstandings may occur with no chance for explanations. A spirit of dissatisfaction may grow up from such misunderstandings and a spirit of unrest spreads and like centrifugal force increases in proportion as it diverges from the center of organization. The germ of the labor agitator will fall upon such a weakened constitution with the chances of a successful culture all in its favor.

Favoritism is another most insidious germ which finds ideal conditions for its growth in such environment.

Relationship is the most virulent form of favoritism known, a most insidious germ, one which is almost impossible to eradicate. It is of the virulent form and is so resistant to treatment that it seems impossible to alter its characteristics. It is so insidious a disease that no matter how watchful one may be it is sure to creep in unnoticed and propagate quietly until you wake up suddenly and discover that you have a malignant cancer in an advanced state of growth which needs the dissecting knife for its removal. As this is often painful, procrastination may follow until disorganization is complete. The worst thing about this disease is that there are so many attractive things about it. A superintendent may put in one of his relatives whom he thinks will be the most valuable man for the place. His judgment may be correct or it may be incorrect, but the fact remains that he has lost his impersonal position from the moment he takes this step. He may honestly intend to be impartial if you will, but partiality must inevitably follow the loss of his impersonal position. In the majority of cases at least as far as my observations go the superintendent hires the man to make a place for him and puts him in a position for which he is totally unfitted. If this man has the power of employing others, you may have a propagation of this disease from this source alone. After the superintendent has followed this course once he will in all probability follow it with some other relation or relation-to-be when the pressure again is exerted. In one of our mills at a time dating before the Brown management assumed control we had a startling example of Relationship. The management moved his main office to Boston and gradually became out of touch and sympathy with his organization. The superintendent put in his own relations and his wife's relatives and I don't know but their relatives until nearly every department in the mill was under one of these parasites.

The mill went down very rapidly and instead of being a profitable undertaking it became a losing proposition. Finally the manager came to town and got more or less in touch with some of his employees and substituted for reports which he believed represented facts, realities as he found them to exist. When told of positions held by relatives and near relatives there was one he could not account for so he asked, "How about the grandmother—is she in charge of the log pile?" Now this manager had the courage of his convictions and did not procrastinate but cut out this cancer, root and branch. He, however, had let it go too far and the results which followed may be attributed perhaps not wholly but to a great extent to the effects of this most insidious and virulent of diseases.

Clannishness may be another cause for dissociation of mill entirety. This usually follows the elevation of a man of foreign nationality to the position of foreman. I have found clannishness very marked in Norwegians, Swedes, and French Canadians, and noticeable, but to a far less extent, in the Irish, Scotch and English. This is a thing which must be watched and watched closely. If this foreman appoints men of his own nationality they will cover up the truth if it affects one of their number and exaggerate any shortcoming of any one outside of their number in order to force him out and fill the vacancy with another of their clan.

If the condition as governed by labor or location is such that a large foreign element must work in the mill, then the best way to meet this condition is to mix up the nationalities in each department so that one nationality may not obtain the preponderance over any other. It will not then be so easy to cover up the defects or faults of which the management should be informed.

Fraternity in the sense I am speaking is a twin brother to clannishness, and what applies to one applies with equal force to the other.

In the above I have shown a few of the more common causes which may tend to disrupt the mill organization and I might mention many others, but I have mentioned these few in order to show that there is one thing that the management should know.

What do the men talk about? What do the men think about?

If you only know what the men think you may be able to make explanations which will enlighten them and give them a different outlook on life. The closer the personal touch between the employer and employee the less is the chance for misunderstandings and the better for both employer and employee.

Do you realize that a man may put down figures which he knows are not the truth and yet never have it enter his mind that he is sophisticating his results? This is not dishonesty because he does not perceive there is any dishonesty in what he has done.

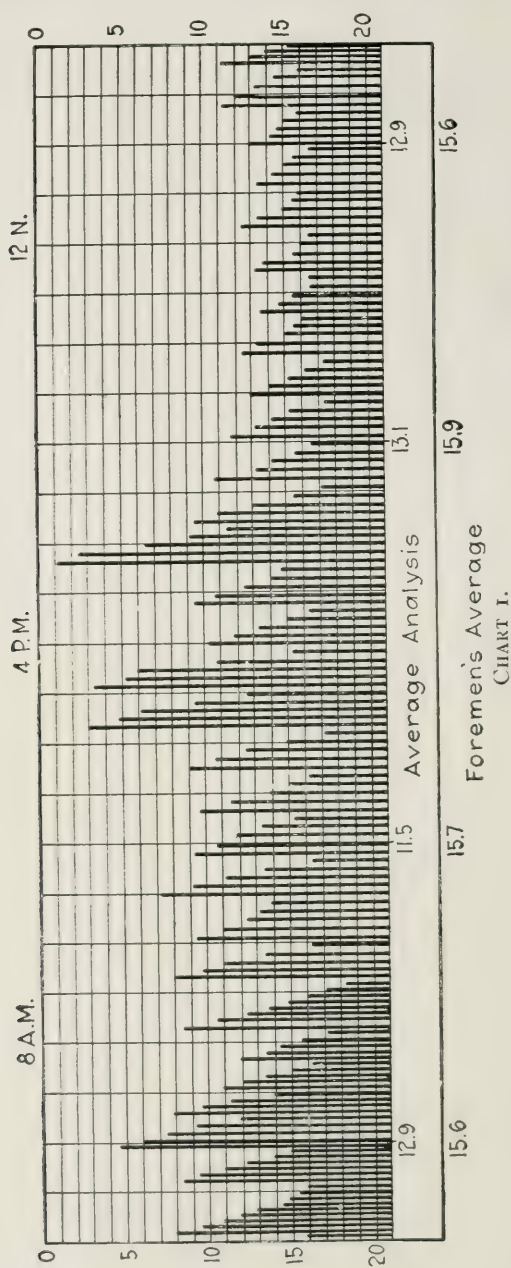
An example of this may be taken from our 1908 records. The operation is burning sulphur with air with the intent of getting the highest possible percentage of sulphur dioxide in the resulting gas. The records on our books show the following results as obtained from hand-fired flat burners used at that time.

PER CENT SULPHUR DIOXIDE GAS

Shift 12 N. to 8 A.M.	8 A.M. to 4 P.M.	4 P.M. to 12 N.
15.8	15.6	16.5
15.0	18.4	14.6
16.6	16.3	11.6
15.8	13.9	17.3
15.8	16.3	16.6
15.8	15.3	17.3
15.8	16.2	17.2
15.0	17.2	16.1
14.0	12.6	16.4
16.4	15.3	
Average 15.6	15.7	15.9

You will see from the above that there is not very much difference between the maximum and minimum readings.

To show that the above is not a true statement of facts, I submit Chart I giving the analyses from a recording machine. It will be observed that the figures given in the above table are only the maximum figures. You see every time the burner doors were opened the large influx of air weakened the gas. Now every foreman soon found out that after a certain time had elapsed after firing, the gas would test a maximum and not sublime sulphur. He always planned then to be on hand at this time to test his gas and actually put down the figures he found by analysis. This in all probability started from one foreman doing this and when the other foremen did not get equally good results they copied the same method. Now these men were not scientifically trained, and when they averaged up their selected results there was no thought in their minds that they were of no value whatever. Furthermore the management going into the mill



and seeing the foreman write down the selected results which he could see were actually obtained on the Orsat had no suspicion as to how far they were incorrect. Had he known what the men were thinking about he would have been "put wise," and would not have accumulated on his books an amount of data which is absolutely valueless. At this time we had installed an automatic recorder. The recorder record of the same shifts shows far different results though the maximum results are approximately the same. Comparing the two we get results as follows:

PER CENT SULPHUR DIOXIDE

	Foremen.	Recorder.
Shifts 8 A.M.-4 P.M.....	15.7	11.5
Shift 4 P.M.-12 N.....	15.9	13.1
Shift 12 N-8 A.M.....	15.6	12.9

Incidentally this illustration shows the value of an automatic machine which records at given definite intervals. Even had the management known of these variations it would have been unable to time the analyses of the different foremen periodically so as to get true concordant results. In the case above (which is given not as an isolated case but as an example of a type) we have an illustration of ignorance, combined with the idea to make as good a showing as possible based on the more or less ever present feeling of self-preservation. Where the superficial observer would have classed the above foreman as dishonest the careful observer cannot overlook the psychology involved. It sometimes happens that the management expects too much of the men. By this I do not mean to state that he does so purposely; in fact, he is unaware that he is expecting too much. He probably does not know the complexity of the problem involved and what is more even if he were on intimate terms with his employees he could hardly find it out as they do not know themselves just what is involved and cannot make it clear to their employers. Here is where the chemist or chemical engineers comes in. He, however, should be democratic, of sterling character, and in full sympathy with his fellow beings. He can then obtain from them what information they can impart and with his more technical knowledge reject that which is bad and adopt that which is good. Above all he should not be a man, "who knows it all." The man who goes around with the air of one "I know it all" engenders

antagonisms and often contempt and discourages suggestions. He may defeat by this attitude the main object of accomplishment which is his task.

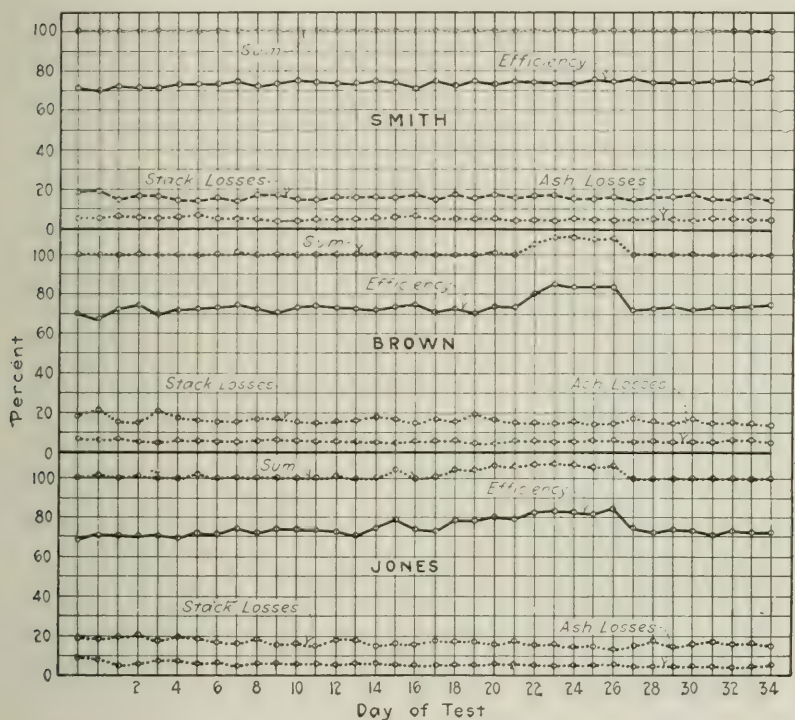
The man constantly with a process or apparatus finds out many details of operation which it is unlikely a man not constantly in touch with it (no matter how able he is) will find out at all. In my experience in mill work I have never run across a man operating a process or device that could not show me valuable points. A lot of opposition to changes which the management wishes to make may be traced to the fact that the management has not taken care to collect the valuable data which their employees have and consequently do not know what they are thinking.

As an illustration I know of a manager who noticing that knots and bark sank while chips of clear wood floated designed a process for their separation by flotation. He told the foreman of his scheme who promptly told the manager it would not work, at least not to such an extent as to make it practicable. The manager, an educated man, thinking it was the ever-recurring opposition to innovations turned on his heel and left the foreman without asking for an explanation. He constructed his machine, installed it, and tried to operate it, and on finding that it would not work finally destroyed it. Later he called the foreman and asked him how he knew it would not work. The foreman took a piece of wood floating in the woodroom tank and cut many chips from the same. They, when thrown into the water, went to the bottom. This foreman from his daily work had observed certain facts which had escaped the attention of the manager. This manager made the mistake of underestimating the intelligence of his foreman. One of the educational tests which is still under discussion is to show an intelligent adult two paragraphs one of which may be an involved subject as, for example, "What is money?" The other may be some trivial description of a group of people. After the adult has read these he is then asked about what he has read. He may be able to give a pretty good résumé of the article which is the more abstruse, but he cannot tell you whether it is the tall boy, slim boy, fat boy or short boy who had pink cheeks, red neckties, etc. If you show these two articles to a child the abstruse one will mean nothing but the trivial one is full of meaning, and he or she can and does remember the details which though read and understood by the adult made no impression.

It is just so with your men in the mill, some see and remember

the minutest details while others may miss these entirely and pay attention only to the principles involved. The strict observance or non-observance of detail is often, in fact is generally, the difference between success and failure provided your basic principle is sound.

In the illustration before given we have shown a typical case wherein men put down results which they knew did not represent the facts and were entirely honest in what they were doing.



Solid line, efficiency, is the only curve known to the foremen. Dotted curves were known only to the investigators. "Stack losses" includes heat lost in dry gases and in water vapor. Radiation loss, etc., not plotted, is assumed constant at 5%.

CHART 2.—BOILER PERFORMANCE CURVES FOR THREE FOREMEN.

I am now going to give a typical example of wilful sophistication and will illustrate it by chart 2 which shows more or less accurately the efficiency of the foremen on each shift in the boiler house. This chart is only illustrative, for in order to save space and in the interest of lucidity it is condensed in time and all the factors are not plotted;

radiation, convection, and necessary blowage, etc., are not plotted but lumped together in a constant called radiation 5 per cent.

The stack losses and the ash losses and the efficiency of the boiler are plotted all in terms of the percentage of B.T.U. contained therein of the original coal, and the sum of these is also plotted. By plotting in this manner we can illustrate our point and yet simplify the matter to such an extent that it is readily understandable to those who have not so to speak made a profession of the study of numerous and complex graphs.

The efficiency curve is the only one known to the foremen and the dotted lines were known only to the investigators. Smith, Brown and Jones are fictitious names.

To the foremen the efficiency meant the amount of water evaporated per pound of coal and this was arrived at by metering the water into the boiler and dividing the same by the pounds of coal used.

It will be seen from the above chart that Smith was an honest man and the amount of heat accounted for did not ever get to an amount over 100 per cent of the heat in the coal than could be accounted for by the errors in observation and calculation. On the fourteenth and fifteenth day Jones probably by accident rather than design blew off more water than was customary. On the sixteenth and seventeenth he ran normally and probably cogitated on the fact of his high efficiency. In his cogitations it occurred to him that he had blown an unusually large quantity of water when he obtained a high efficiency and from then on Jones purposely blew an ever increasing amount of water through the blow-off.

Brown also had been cogitating over the high efficiency of Jones and finally gets wise but he overdoes it and his efficiency jumps to 86 per cent. Now the graphic department in plotting all the curves noticed that the total B.T.U. accounted for reached as high as 110 per cent of the B.T.U. in the coal. They report it to the chemical engineer and he sees where the plant is not complete and perhaps he talks with Smith. At any rate on the twenty-seventh he installs a tank capable of standing the full pressure of the boiler and pipes the blow-offs of the boiler to this tank. By this means certain deductions can be made and the efficiency as figured from the input of water to the boiler is corrected. It will be observed that the efficiency of both Brown & Jones dropped while that of Smith did not change upon installing the tank. Incidentally I might add that about this time we tried the bonus system in the boiler room. It did not work,

first because one man usually got the bonus so that it either discouraged the others or made them jealous so they would do anything in their power to leave their fires in such a condition as to hamper the successful man and second it was a direct invitation to get apparent results more by sophistication than by actual efficiency. As a matter of fact the posting of the results of each foreman gave much better results and the bonus system was abandoned. Here again had we had some means of knowing what the men were thinking we might have saved a lot of expense and worry and obtained better results.

I have given an example of the management underestimating the intelligence and powers of observation of the employees. To underestimate the difficulties encountered by the man while perhaps not of as great importance as the foregoing is still of sufficient importance to warrant its mention.

In all probability most chemical and metallurgical operations are carried on by men who have had no training in chemistry or metallurgy. By long experience a man may obtain a technique which will enable him to carry on an operation successfully even though the same may be complicated by many variables. Now if these men are organized they may if they so desire exert a pressure on the mill management all out of proportion to their numbers. This is especially true if the operation they control is a fundamental part of the operation of the plant. I have seen the time when six men not only had the power but exerted it to shut down the largest mill of its kind in the world. They realizing this fact made most exorbitant and unscrupulous demands. Here again had the management possessed the information which the men had obtained this thing would have been impossible. Now here is an operation containing many variables with the possibilities of spoiling a cook far in excess of the possibilities of making a cook (see Appendix), and with so many variables the probabilities are that though they may get by on making the cook the products of separate cooks are not uniform but may vary greatly. Now if you want a carpenter to make a house you do not cut all his lumber for him and tell him "Everything is ready, now build your house." The carpenter would tell you to give him the picture or plans of the house and he could cut the lumber himself.

In the same way the operator of a complex chemical operation would like if it is possible to obtain a picture or plan of this operation. The more complex the operation the more ingenuity must be

exercised to obtain a picture which means something. As an illustration Chart 3 shows an actual digester cooked in 1911. (See Appendix.) On this chart the ordinates are pressures and the abscissæ are time in hours. The three pressures plotted are Gauge Pressure, Steam Pressure and Gas Pressure. When we first started this system we found it very difficult to make the men understand that a pressure below atmospheric pressure was a real pressure so we plot those pressures below atmospheric pressure as minus pressures, and a table of the pressures corresponding to temperatures of steam is given to every cook. Thus, 158°F. would show as pressure on this chart as -10 pounds while 250°F. would show as $+15$ pounds. Now the gauge pressure* is plotted and the steam pressure* corresponding to the temperature is also plotted. The difference between these two is the gas pressure which is also plotted. Now inasmuch as it is the SO_2 gas which does the cooking this picture shows the cook if he is blowing off his gas too fast. The crosses on the chart are placed in place of figures for the reason that we are dealing in principles and it is not our object to give away private information of the mill. The cooks are taught to plot these charts themselves and in so doing they correct their cooking procedure. Having established the value of the chart we at once placed ourselves in a position to demand uniformity of results. This example is an illustration of how the management formerly expected too much of the men when they asked for greater uniformity of results than they got.

This chart has another value in that it is now possible to do experimental work in the laboratory and draw the desired chart which we may reasonably expect to be duplicated by the cooks in practice.

Chart 3 was made in 1907. Chart 3A shows four of these cooks and you will notice the striking difference between them. Chart 3B was made also in 1907 but later. You will notice that the cook began to blow off his gas too fast and was checked by instructions. I should like to show you several more of these charts which were made at this time but lack of space forbids. Suffice to say that no two are anywhere near alike. Compare chart 4 which was made in 1911 with chart 3 and the difference is striking. Chart 4A shows four of these cooks and the similarity is striking. For obvious reasons I do not submit any of the present day charts.

* See Appendix.

1907 MILL COOKING REPORT

	Hrs. after Steaming	Time	Tem- perature	Gauge Pressure	Steam Pressure	Gas Pressure	Percent SO ₂
Cook No. 56							
Digester No. 6	0	6					XXX
Date, 1907	$\frac{1}{2}$	6.30					XXX
Filling Time xxx	1	7	145	10	-11.3	21.3	XXX
Steamed at 6 a.m.	$1\frac{1}{2}$	7.30	151	14	-10.8	24.8	XXX
Blown at 4 p.m.	2	8	157	19	-10.3	29.3	XXX
Hours Cooked 10	$2\frac{1}{2}$	8.30	161	28	-10.	38.0	XXX
Steamed by xxx	3	9	170	38	-9	47.0	XXX
Blown by xxx	$3\frac{1}{2}$	9.30	190	68	-6	74.0	XXX
Blowing Test xxx	4	10	195	77	-5	82.0	XXX
Acid Temp. xxx	$4\frac{1}{2}$	10.30	207	62	-	64.0	XXX
Test: Total xxx	5	11	246	67	13	54.0	XXX
Free xxx	6	12	272	71	29	42.0	XXX
Comb. xxx	$7\frac{1}{2}$	1.15	299	72	52	20.0	XXX
	8	2	315	72	69	3.0	XXX
	9	3	321	78	75	3.0	XXX
	10	4	318	78	72	6.0	XXX
	11	5					XXX
	12						XXX

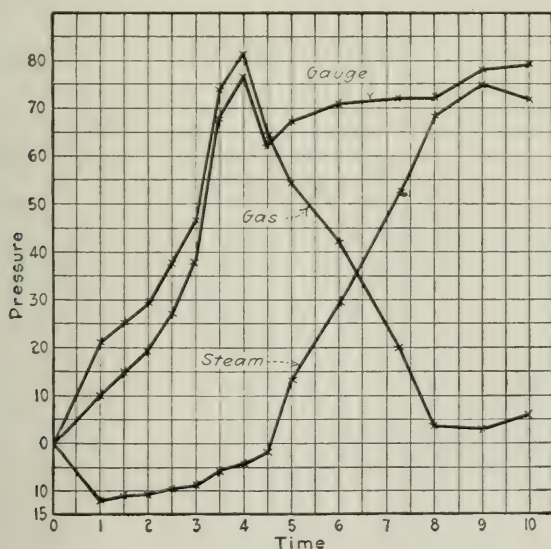


CHART 3.

Chart 3a.

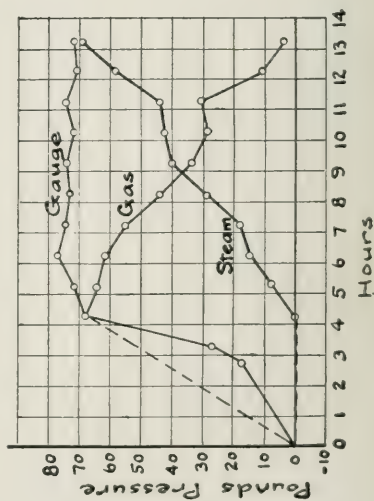
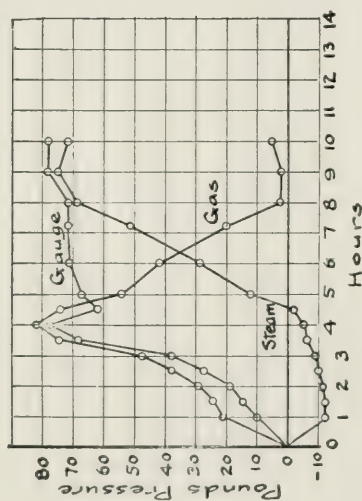
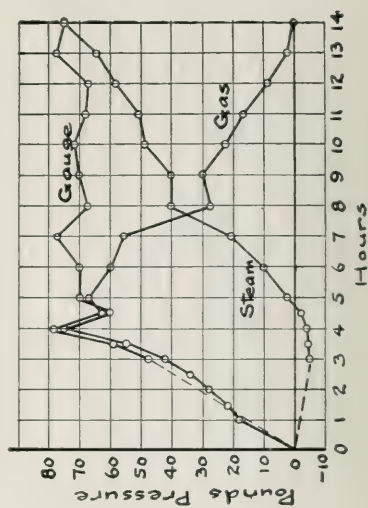
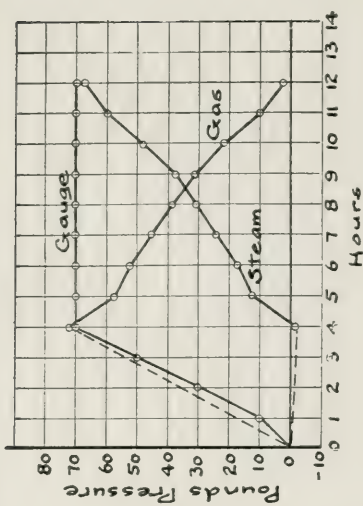


chart 3b.

MILL COOKING REPORT

Cook No. 57	Hrs. after steaming	Time	Temperature	Gauge Pressure	Steam Pressure	Gas Pressure	Percent SO ₂
Digester No. 13	0	6:30					xxx
Date May 17, 1907	1/2	7:00					xxx
Filling Time xxx	1	7:30	134	7			xxx
Steamed at 6:30 a.m.	1 1/2	8:00	130	14	-12	26	xxx
Blown at 7:30 p.m.	2	8:30	130	23	-12	35	xxx
Hours cooked 13	2 1/2	9:00	155	36	-10	46	xxx
Steamed by xxx	3	9:30	180	53	-7	60	xxx
Blown by xxx	3 1/2	10:00	188	64	-6	70	xxx
Blowing test xxx	4	10:30	205	68	-2	70	xxx
Acid temp. xxx	4 1/2	11:00	255	68	18	50	xxx
Test: total xxx	5 1/2	12:00	271	74	28	46	xxx
free xxx	6 3/4	1:15	254	63	17	46	xxx
comb. xxx	7 1/2	2:00	255	63	18	45	xxx
	8 1/2	3:00	274	70	30	40	xxx
	9 1/2	4:00	281	72	35	37	xxx
	10 1/2	5:00	288	77	41	36	xxx
	11 1/2	6:00	300	72	53	19	xxx
	12	6:30	305	72	58	14	xxx

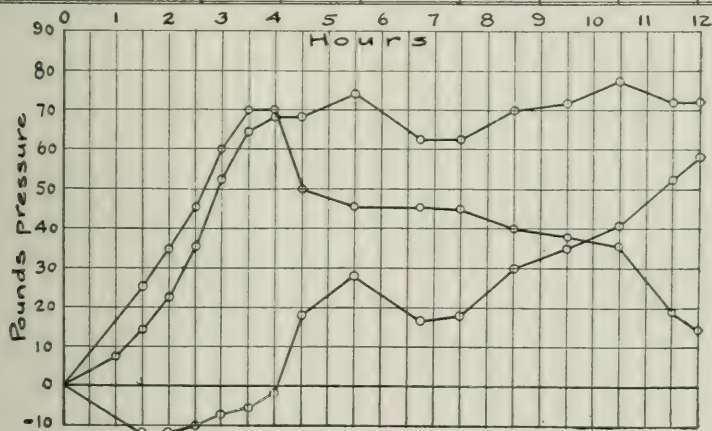


CHART 4 COOKING RECORD

DIGESTER NO. 15 COOK NO. 77 DATE Nov. 28, 1911

Previously Blown at XX

Steamed by XXX

Filled, Cover on and Soaking at XX

Blown by XXX

Steamed at XX

Blown at XX

ACID WHEN FILLED

Total SO₂ XX

Free SO₂ XX

Combined SO₂ XX

Temperature XX

TIME IN COOKING

Time from last blow to cover on XX

Time soaking before steaming XX

Time steaming XX

Total time blow to blow XX

Time to pressure after turning on steam XX

COOKING TESTS

Relief first shut off at XX test XX

Relief again shut off at XX test XX

Steam shut off at XX test XX

Hours after steaming	Time	Temp.	Pressure			SO ₂
			Gauge	Steam	Gas	
0	XX					XX
1	XX		22			XX
1½	XX	170	41	-9	50	XX
2	XX	195	70	-4	74	XX
2½	XX	218	75	2	73	XX
3	XX	225	75	4	71	XX
3½	XX	227	75	5	70	XX
4	XX	233	75	7	68	XX
4½	XX	246	75	13	62	XX
5	XX	252	75	16	59	XX
5½	XX	259	75	20	55	XX
6	XX	262	75	22	53	XX
6½	XX	265	75	24	51	XX
7	XX	273	75	29	46	XX
8	XX	280	60	34	26	XX
9	XX	282	62	36	26	XX
10	XX	280	43	34	9	XX
11	XX	276	38	31	7	XX

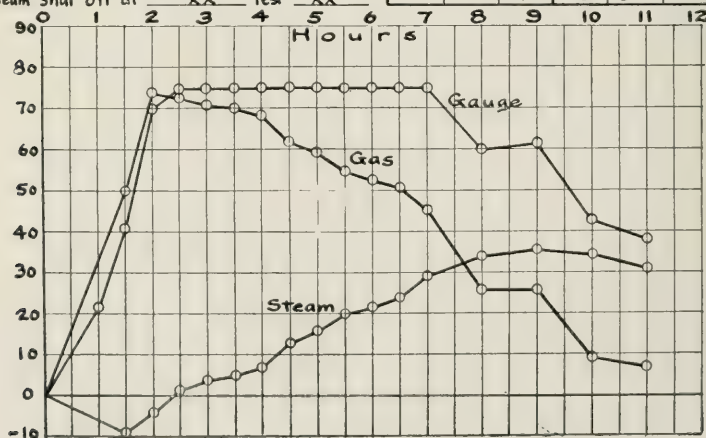
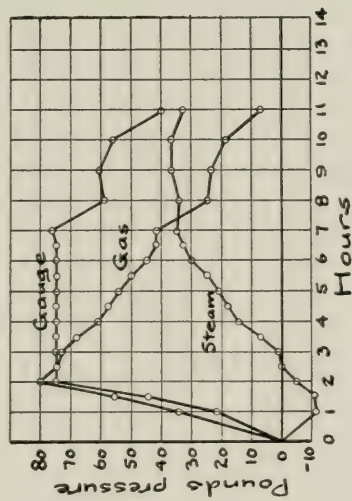
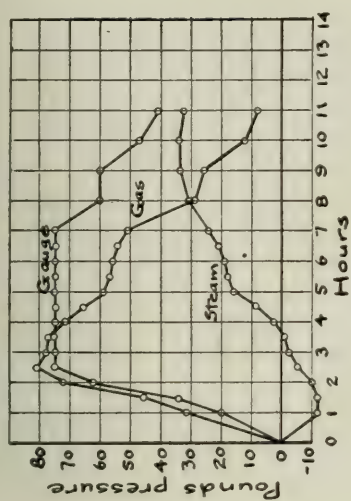
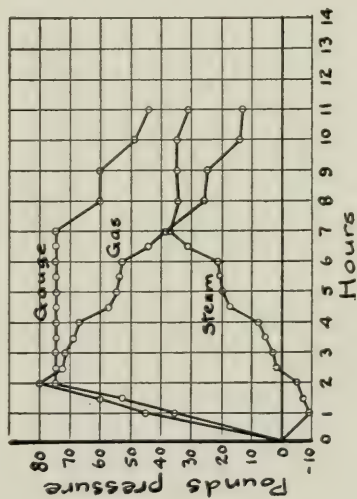
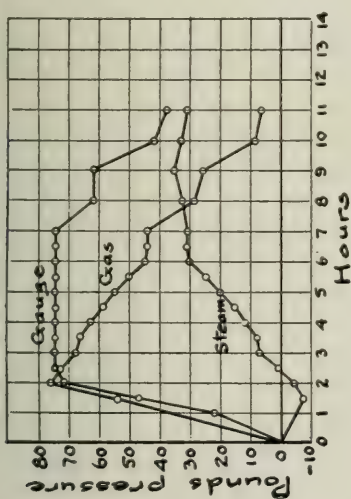


Chart 4a.



The above is given as an illustration of how the management should help and guide its employees. I should like to go into examples of the above more at length but space forbids.

There is a great tendency among manufacturing plants to hide the light of their employees under a bushel basket. This is a narrow and shortsighted policy and while the management may save a few dollars in salary the intangible loss far outweighs the small amount saved.

As an illustration of what I mean I may give the policy of our own research laboratory as compared with the general attitude of laboratories over the country. When we hire a man we try to impress upon him that in considering his compensation he should not consider his salary as his total compensation. The reputation which he is enabled to make is as much a part of his compensation as his salary. We do not stand in the way of a man obtaining a wide reputation: we even aid him to get the same. This not only gives him an idea of what he is worth by enabling him to receive offers from the outside world which he otherwise would not have received, but it also informs the management that if he is worth so much to an outside organization he is worth as much or more to our organization. You will say, "I can see how this benefits the employee, but how does any such policy benefit the mill?" The answer is that such a policy tends to produce what I may term the Stimulation of the Initiative. And above all this policy tends to create respect and confidence which are the foundation stones for loyalty and good service.

Before going into this I want to say a word about Habit and will quote Dr. Wm. H. Thompson as far as is possible without making this of undue length. Dr. Thompson has shown that in the lowest animals which show a trace of nervous system there are three parts: (1) a nerve filament which receives and transmits a stimulus to (2) a nerve center of soft gray cells on fibres which receive this stimulus and which center reacts to this stimulus, never on the nerve which brought it but on (3) a nerve filament which proceeds from the center. The first is called afferent because it transmits to, the second efferent because it transmits from. Step by step the nervous system can be traced in animals still absolutely brainless to the more highly developed nervous systems and as organization proceeds one finds an increasingly greater number of nerve centers each with its afferent and efferent nerve, but with one important addition, namely, that

the separate nerve centers are connected by short nerve fibres which are for the purpose of enabling the centers to work together. A still further development, a regular chain of such nerve centers forming a distinctly ascending series whose functions never change or abolish the original afferent and efferent mode of working but instead show a more perfect harmony of action between the several parts.

After a certain number of nerve centers become associated we find the mutual coöperation of the centers begins to be plainly more frequent in certain directions than others, that is that it seems easier for the centers to act together to execute some movements than to execute other movements. Examination proves that this is due to the more frequent repetition of certain afferent stimulus than other afferent stimuli.

Thus we have habit, whether in man or animal due to the slowly acquired habits of these centers which acquired their habits from innumerable repeated afferent excitations along their respective nerves in habituating the efferent motor nerves to act together. (Appendix of frog.)

Thus as the development of the nervous system proceeds it extends not only to control of the motor nerves but develops nerve centers in the brain which are also connected together by nerve fibres and we get mental habits in much the same manner as we obtain physical habits, with this exception, that instead of the formulative stimuli coming from without it comes from within that we have substituted design for automatism. Now the brain originally is no different from any other nerves and is developed in much the same way by the constant repetition of stimuli. The thinking brain is also developed in the above manner, but the stimulus comes from within instead of without and that the stimuli are exerted by the personality through the will. Thus we find the remarkable fact that a personality makes his own brains. The constant application of stimuli by the will results in a slow but sure growth of that part of the thinking brain which receives the stimuli.

Dr. Boris Sidis recognized this fact when he said he could make any boy a mathematician if he started with him before he reached the age of six.

Thus constant application of stimuli to different centers of the thinking part of the nervous system produce habit just as surely as to the bodily nervous system so to speak. But it must be remem-

bered that this habit is physiological. As a rule men over fifty seldom show any capacity to be converted; this is not due to an enfeebled judgment due to middle age for it is usually stronger if left free to act. But as years pass the judgment is less free to act. Those elements, likes and dislikes, etc., have been steadily fashioning the mind's physical instrument to work out only opinions to match, until to have new opinions they literally need new brains.

The will causes certain stimulation of the nerves in definite locations in the brain and that constant repetition of these stimulations actually causes physical change. Thus the power of speech, music, language, mathematics, etc., are all self-created and created in proportion to the ever-recurring question as to how you stimulate the initiative if it does not exist.

Thus the management if it is to develop its men must not only create initiative but habit.

Now let us go back to the stimulation of the initiative. We find first that the policy above outlined not only informs the employer what he is worth but it informs the employee. It is very natural that an employee should get an exaggerated idea of his own importance. If, however, he finds that others besides his employer do not accept him at his own valuation he will modify his ideas. He can no longer take the attitude that if he could get out into a wider world that he would be more appreciated. His reputation is what he makes himself and he receives full value according as he makes his reputation. Having now obtained a more or less true estimate of his own value he immediately starts to build up for himself a reputation and this can only be done by rendering valuable service. Here then may be a starting point for the development of the initiative. But it is not sporadic attempts which cause development; it is the constantly exerted force of the will which must be applied to allow physical growth to take place with the consequent mental growth. A dissatisfied employee will never exert the constant effort of the will to develop even though it be in his own interest as well as his employer's. As an example of the application of the following principles I wish to state that in one of our mills our chemists began to develop the much-desired initiative. I was called away and was constantly out of touch with these men for four years and did not see much of them for two years more. During this time the man to whom they were directly accountable also tried to develop in these

men the personal initiative but defeated his own purposes by not giving the men the credit which was theirs.

Instead of taking out joint patents with these men he took them out in his own name and while he talked and lectured on mill organization he never gave due credit to those who helped in this work and while as a rule he did not claim directly all credit for this work, he nevertheless got the entire credit by implication. The result of this procedure was the entire destruction of the incentive which stopped the development of the initiative. During this entire time there is no credit to this concern for patents taken out by these men, neither so far as my knowledge goes are there any publications by which these men could receive due credit from business men and others in their profession for that which they had accomplished. It is our problem to make conditions such as to recreate as far as possible the lost initiative. This is a far more difficult problem than formerly because the nerve tissues are less plastic and less susceptible of change by excitation than was their condition eight years ago. In the formation of Habit it is essential as far as possible to avoid misdirected Habit which becomes more or less of a stumbling block. Right here I wish to state that it is a great mistake to put a man in charge of the execution of a problem on which he has formed the preconceived opinion that its successful solution will be impossible. The successful solution of a problem may or may not be possible, but if you have determined to try and solve this problem after hearing all arguments pro and con, then the way to start is to put its execution in charge of a man who is an optimist as far as this particular problem is concerned. Here again we have an illustration of Habit. Every failure of the man who believes this cannot be done, and there will be many, will only tend to confirm him in his preconceived belief that it cannot be done and repeated failures simply stimulate the habit of unbelief as far as this problem is concerned. We have seen a very good illustration of this principle in the last three years. We had such a problem and the superintendent of one of our mills put a man of marked ability in charge of its execution. The marked ability of this man was recognized by the government sending him to France, putting him on General Pershing's staff as a chemical engineer with the rank of captain. Nevertheless he was a pessimist as far as this problem was concerned and nothing but discouraging results were forthcoming. When he left, the solution of this problem was sought by the same staff with the exception of this man and

solved with the greatest success. The remark which he made upon being told of the successful solution of the problem, viz: "I am from Missouri, you will have to show me," illustrates his mental attitude as far as this problem is concerned.

Now when you realize that mental growth is the product of constant application of the mind you will readily see that the management if it gives up a problem too soon, before chance for mental development has had a chance to take place, makes a great mistake.

I worked on one problem off and on for seven years; on another problem I worked three years and on the one just mentioned over three years. Two years is a short time to solve a real big problem. Now from what has been said it will be seen that the changing of an executive in charge of a problem, unless he proves himself radically unfit, simply because he does not arrive at the solution immediately is a grave mistake. The executive has this problem before him night and day and this constant excitation of this part of the brain is producing a slow but nevertheless sure development which if the problem is not impossible must lead in time to its solution. Now if constant changes are made in the executive in charge the new man has to go through all his predecessor went through before he has reached the same mental development. If then other changes are made the foregoing is repeated and the management has nothing to its credit but a large experimental expense. The management should be careful in choosing the man who is put in charge, but having chosen a man it should continue this man on this problem until results are achieved or until it has made up its mind that a successful solution will not pay dividends on the amount of money required for its solution. As mills go, far too many problems are abandoned before a fair trial has been given owing to the non-observance of these principles.

I have spoken in the above of the mental attitude of the executive in charge of the successful solution of a problem and laid down the principle that he should be a believer in its successful solution from the start, and now I want to say one word as to the attitude of the management in regard to suggestions coming from those responsible to it. It must be constantly borne in mind that the management puts his capital in these operations and that it will suffer for all mistakes it makes as well as the mistakes of its employees and that consequently its decision should be final good or bad. But it often happens that it can reap benefit from the mistakes it makes as well as penal-

ties. The wise management will allow certain leeway (within certain limits) to its chief executives as they after all carry out the policy of the management.

For instance, a foreman may come to the executive with a proposition which that executive knows from past experience will not work. He may turn it down absolutely or he may consider after figuring it over that he will allow the foreman to try it and fail and convince himself. I have done this many times myself and have obtained results from the changed mental attitude of the men which far outweighed the small expense involved and sometimes I have seen how to make suggestions from the failure which may change the failure into more or less of a success. In case of foreordained failure, so to speak, I always put it up to the man himself and give him my heartiest support so that when it fails he can have no comeback. If, as sometimes happens, the management is mistaken and the man gets the solution, the executive should not be grudging of his acknowledgment, but take off his hat to him, so to speak, in a wholehearted manner. This tends to produce not only coördination but coöperation and the esprit de corps which we are striving to obtain.

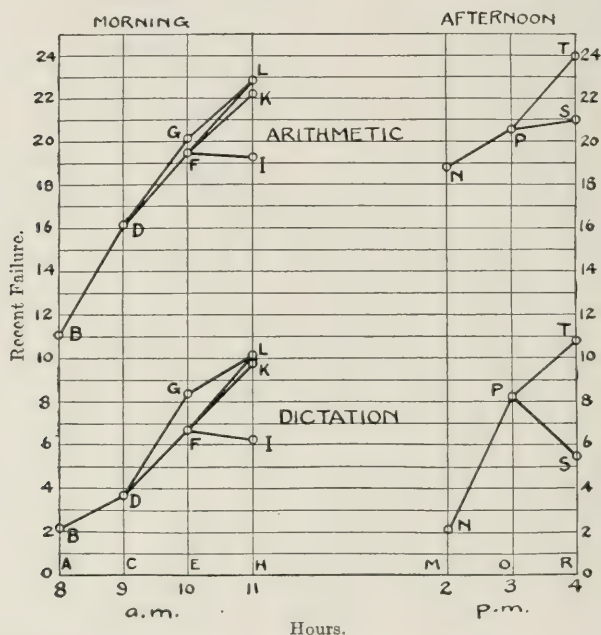
The subject of habit is indissolubly connected with that of fatigue. Just how many of you know what fatigue is scientifically? Fatigue is a general condition produced by the products of dissolution which accumulates either brain work, nerve work, muscular work, or growth. Weichardt gave the term kenotoxins to these products. He even went so far as to extract some from a tired animal and inject the same into a fresh animal and thereby produced all the characteristic signs of fatigue. It used to be thought that a change from mental work to physical work would diminish fatigue, but this has been found not to be the fact. Any kind of work irrespective of whether it is nerve work, mental work, or muscular work produces fatigue, and there must be sufficient time allowed in the way of recesses to allow the accumulation of the kenotoxins to be carried off by the blood through the lungs.

The writings of Carl Barth and the late F. W. Taylor on this subject are so recent that anybody interested in the actual application of the principles can refer to them as far as the physical work and nerve work are concerned. Perhaps the investigations as to mental work are not so well known. In the appendix will be found Chart 5 representing some of the work of Frederick of Halle, Germany, show-

ing the average effect of fatigue on a large number of school children. See Appendix.

In this chart is an illustration of mental fatigue in the subjects of Arithmetic and Dictation, but it must be borne in mind that any kind of nerve action whether mental or physical causes the formation of these kenotoxins. Hate, dislike, worry, etc., all cause fatigue and it is one of our objects to remove as far as possible all such causes and how we endeavor to do so will be shown later in this paper.

Chart 5



I may, however, give you one illustration right here of the practicable application of this principle of this mill. When you go into the wet machine room you will notice that there are always two sets of men at work on the wet machine. Owing to the strenuous character of this work the kenotoxins of fatigue accumulate much faster than they do from work in other portions. One man cuts off the machine while the other putters around oiling, cleaning up, etc. This second man is resting. After he has become sufficiently rested, he takes the place of the first man and so they alternate back and forth. No time studies have been made here but these men arrange their work-

ing and puttering periods between themselves. The early recognition of this principle accounts for the fact that these mills were one of the first in the country to adopt the three shift system. A new and unaccustomed kind of work may also cause fatigue from the very fact that it is not habit and therefore calls for a greater expenditure of nervous energy. For my illustration I will take a case at La Tuque. In making a gas producer test and furnace test combined I not only had to use all the men in the office, but those men in the mill whom I thought reliable enough to trust to their results. I took one man from the Wood Yard and put him measuring the amount of liquor drawn from a barrel. After he had been at it a few hours I said to him, "Well, Baptiste, you have a soft snap to-day." He replied, "Oh Monsieur Moore, this is awfully rough work; put me back on the log pile." And I had to do it for he was used up. Lack of habit of simple subtraction caused so much fatigue that he was used up in a few hours, though I doubt if he made fifteen subtractions an hour.

In this one case we see the necessity of putting a man on a job to which he is accustomed by habit, and having accustomed your men to their various jobs it must necessarily follow as an economic result both for the man and the organization that conditions shall be such that the employee shall keep his job until he educates himself and likewise forms habit for another job.

Magnus W. Alexander has recognized this fact and has tried to reduce its economic effects to figures. He, however, only takes the question from the side of what it costs the employer to hire men and train them which is another word for habit. He shows that the cost of hiring men varies from \$8.50 for unskilled labor to \$73.50 for skilled labor per man for new employees, for rehiring employees all the way from \$5.00 to \$35.00 per man. The skilled employees are assumed to have been skilled in their trade and this additional expense is the cost of forming additional habit for the additional details required by the man working at his trade but under different conditions.

If some one could write the compliment to this work and reduce to figures what it costs the employee to change his job, it would not only be instructive but it would tend to stabilize labor and be of mutual benefit to the employer, employee and community.

Having now touched upon the basic principles involved, let us see how we try to carry them out in a practical way. In the first

place the Brown Company believes in giving just compensation for services rendered and always takes the lead in raising wages as conditions warrant it. The initiative in this respect always is taken by the Company and never comes through the employees. But wages are not everything in a town, and I cannot make this clearer than by quoting the following statement from Theodore Roosevelt's "Foes Within Our Household," "The philosophy of the belly never gets a community very far." Statistics prove this. We find that where farm or village people are making money the fastest they are going to the cities the fastest because in the cities they find schools, household comforts, entertainment, society, and other things for which they wish to spend money while they are well, and when they are sick in the cities they can find more than antediluvian hospital facilities at something less than multi-millionaire prices.

From the very beginning when the Berlin Mills was a small concern with only a few employees, Mr. W. W. Brown started in by giving to each of his employees a turkey on Thanksgiving Day, and this policy he continued to the date of his death. The same policy has been continued ever since by his sons even though the number of employees has increased so enormously that the expenditure thus entailed amounts to many thousands of dollars. When the Burgess Mill was built (this is now part of the Brown Company) Mrs. George Burgess, realizing the crying need of education, founded and financed the Night School.

In this town we have a large number of Norwegians and Mrs. H. J. Brown, realizing that they were cut loose from their own literature and that there must be a period of adjustment before they could accustom themselves to the conditions in this Country, founded and financed a large library in the Norwegian language. To supplement the good so obtained the Brown Company also originally financed the Norwegian Church.

Observing the drunkenness, crowded houses and depravity among the Russians the Company got a priest and financed a Russian Church, having one of the Company's men on the Board of Trustees. This is a community center for the Russians and at times is used for a night school.

In primitive days the neighbor used to come in to do what he or she could in time of trouble and we have what we may term the neighbor spirit. As the community grew larger this neighbor spirit gradually became less until it entirely disappeared. Of course, the

Company cannot prevent this, but in order to combat this tendency as far as possible it has established Public Health Nursing Service, the establishment of which should be credited to Mrs. O. B. Brown. This is not confined to the employees of our Mills but is extended to the public. Not only this but it extends to villages six and eight miles beyond here. Not only this but it is spreading to the schools and is a co-worker with the Board of Health and others connected with health problems.

Four nurses are constantly employed and their transportation is provided for by furnishing them with carriages, automobiles, carfares, and railroad trips as the case may be.

Over one hundred families are visited each month and over seven hundred visits made. The charge is nominal to those able to pay, but those unable to pay will receive as good attention, perhaps better, because of their greater need. Eight thousand two hundred and seventy-five visits were made last year.

The supervising nurse of surgical dressing of the Red Cross Chapter is furnished by the Company and salary paid by the Company.

Of the thousands of dollars for such expenditures last year only five hundred and sixty-three dollars were taken in cash receipts.

The Nurses are not, however, almoners of the Company's charities but report the needs.

Company's Charities.—Owing to the delicate nature of the Company's Charities nothing will be said about this, but there is an average field of need amply met in other ways than stated above by the Company.

In addition to the above a Public Kindergarten is maintained by the Company and fills a much-needed want.

Mr. W. W. Brown, realizing the crying need of a place where men and boys could gather together under good conditions and form good habits rather than the reverse gave \$40,000 to start the Y.M.C.A. Realizing the fundamental fact that appreciation follows in those things in which one has invested his money, he left the remaining \$45,000 to be raised by as many individuals living in town as possible. The phenomenal success of this enterprise to a large extent is due to the early recognition of this principle. This has been built and half of the money needed for its financing is paid by the Company.

Having furnished a social center for the men and boys of the town, Mrs. O. B. Brown felt the need of a social center for the girls

of the town also, so the Company founded the Girl's Club. Any girl who is moral is eligible from the age of fourteen until married.

Social distinctions are forgotten while in the Club and all girls while here must associate with the others and be nice to them. This Club is open from 10.00 A.M. to 10 P.M., Sundays included, and the girls can have their parties, dances, etc., here if they so desire. Besides Class Rooms, etc., they ordinarily have two tennis courts and the Club furnishes rackets and balls.

At the beginning of each year Mrs. Brown discusses the programme for the coming year and this year they are devoting all their attention to Relief Work. Girls Clubs are in Liberty Loan Drives. They have classes in dancing, psychology, First Aid, etc. They also have organized here the Waumbeckkt Group of Campfire Girls. But I must not give too much time to this as I have still many other things to speak of.

The Brown management is not only following a policy of making conditions such as to produce good habits of thought and action, but it tries to co-operate with the men in destroying bad habits. For example, if a person has contracted the drink habit and really wishes to break himself of this habit the Company will send him to the Keeley Cure keeping his job open for him until he returns.

When employees have passed their age of usefulness, they are given jobs which they can fill and so feel independent and yet feel that they are part of the organization. The same is true of those who have had the misfortune to have accidents.

In the foregoing I have spoken of how the management through its various activities which were more or less isolated have tried to improve the conditions in the mill and the town, but I have not spoken of attempts of co-ordination of these men themselves.

After the disorganization in one of our mills already alluded to Mr. Wolf took charge. When the Browns took over the management of this mill, Mr. Wolf, also recognizing many of the basic principles involved, also entered into the executive work of social welfare of his employees and that of the town. He took a great interest in this work and was a great influence in helping carry out some of the things before alluded to, such as Russian Church, Y. M. C. A. But in addition to the foregoing he created a community spirit in the mill of which he had particular charge.

There is not space in this paper to tell of all his activities, but I must mention one which has had far-reaching consequences.

This was the formation of the minstrel show. He proceeded to get an out and out optimist, one who was exceedingly democratic in his ways and one who through his knowledge and association and respect of his fellow men sought and found their good points beneath whatever veneer they may have hid themselves. This man was Harry Raeburn. Five years ago he started this show despite all discouragements and produced the biggest thing ever in Berlin of its kind. The men were surprised at what they could do. You must realize that every one in this show is a worker in one of our mills. The orchestra was composed of ninety men. This undertaking is absolutely democratic. To show how true this is, the men at one end were composed of the chemist in charge of this mill and a tin knocker; I forget about the other end. The principal parts were taken by the mill departments, while the department heads, engineers, etc., sat in the chorus. In training these men you get to know them and realize that we all belong to one great family, our fellowmen, not only this but in getting to know the men we are able to place them in positions for which they are fitted. By giving this every year, we are, so to speak, creating ability in accordance with the principles herein before stated. It is not simply a minstrel show now but a spectacular production. Even the words and music are written right here. This is not a mediocre show at all. I have seen worse in some of the best theatres in New York. People come from many parts of New England just to see this. All profits go to Brown Co. Relief Association for exceptional cases not therein provided for. We also have the Mill Band with a competent leader. This is equal to if not superior to most of the city organizations of the equal number of pieces.

We also have a Men's Glee Club composed mostly of mill men.

In addition to the above we have the Brown Company Relief Association. Every employee may join. If he pays \$1.00 every four weeks it insures him for \$10.00 a week while sick or laid up. The Company pays half the running expenses of this Association. This is run by the men themselves who choose their own officers. If there is any unexpended balance, this is paid back in dividends; for example, 62 per cent dividends were paid back last year.

This Association thus pay to themselves their own money and thus it is tied together, for every member is vitally interested in how this money is expended. This makes each man more careful to report any chance for accident to the proper authorities, thus apply-

ing the Christian principle of making each his brother's keeper. Seventy-five per cent of our employees belong to this Association.

The By-Laws will be found in the Appendix.

This Relief Association is not, however, a substitute for the regular insurance of men as is done by most Companies, for in addition to this we have the regular insurance with the exception that it is run by the Company instead of insuring in outside Companies. If a man is injured he gets his wages and his hospital bills and his family are taken care of while he is laid up. Thus every man is taken care of and those who belong to the Brown Company Relief Association may draw from both sources. The Company has three doctors and realizing that the doctors were considerably handicapped by their lack of the modern equipment which is usually considered far too expensive for all but large cities, the Company contributed a large part of the money needed for buying this equipment.

The Company has lately adopted a policy by which their employees in the Mill may have, if they so desire, a thorough physical examination by an expert. The results will be given to the applicant's doctor with recommendations as to what is needed.

I might speak of many other activities of the Company, such as Hospitals, Churches not before mentioned, facilities for recreation, the Rifle Club, Accommodations for State Guard, activities in Thrift Stamps, Liberty Bonds, etc., but the object of this paper is not to catalog the Social Activities of the Company, but to show how the fundamental principles laid down in the first part of the paper are applied.

It must be remembered that the uniting of everybody in a common service can only be beneficial to all those connected therewith. Such service not only promotes a community spirit in all those involved therein but the effect of the same radiates to all parts of the community.

In conclusion I wish to say that it is our object to make our people more prosperous and self-reliant with happier and fuller lives, but above all we endeavor to make them less selfish and readier to sacrifice themselves for an ideal.

Brown Company, Berlin, N. H.

STEAM PRESSURE IN POUNDS CORRESPONDING TO TEMPERATURE
FAHRENHEIT

Tem.	Pres.	Tem.	Pres.	Tem.	Pres.	Tem.	Pres.	Tem.	Pres.	Tem.	Pres.
121	-13	158	-10	195	4	232	7	269	27	306	59
122	-13	159	-10	196	4	233	7	270	27	307	60
123	-13	160	-10	197	4	234	8	271	28	308	61
124	-13	161	10	198	-4	235	8	272	29	309	62
125	-13	162	10	199	3	236	8	273	29	310	63
126	-13	163	10	200	3	237	9	274	30	311	64
127	-13	164	10	201	3	238	9	275	31	312	66
128	-13	165	9	202	3	239	10	276	31	313	67
129	-13	166	9	203	2	240	10	277	32	314	68
130	-12	167	9	204	2	241	11	278	33	315	69
131	-12	168	9	205	2	242	11	279	34	316	70
132	-12	169	9	206	2	243	12	280	34	317	72
133	-12	170	9	207	1	244	12	281	35	318	73
134	-12	171	9	208	1	245	13	282	36	319	74
135	-12	172	8	209	1	246	13	283	37	320	75
136	-12	173	8	210	1	247	14	284	38	321	76
137	-12	174	8	211	0	248	14	285	39	322	78
138	-12	175	8	212	0	249	15	286	40	323	79
139	-12	176	8	213	0	250	15	287	40	324	81
140	-12	177	8	214	+1	251	16	288	41	325	82
141	-12	178	8	215	1	252	16	289	42	326	83
142	-12	179	7	216	1	253	17	290	43	327	85
143	-12	180	7	217	2	254	17	291	44	328	86
144	-12	181	7	218	2	255	18	292	45	329	87
145	-11	182	7	219	2	256	18	293	45	330	89
146	-11	183	7	220	3	257	19	294	46	331	90
147	-11	184	7	221	3	258	20	295	47	332	92
148	-11	185	6	222	3	259	20	296	48	333	93
149	-11	186	6	223	4	260	21	297	49	334	95
150	-11	187	6	224	4	261	21	298	50	335	96
151	-11	188	6	225	4	262	22	299	51	336	98
152	-11	189	6	226	5	263	23	300	52	337	99
153	-11	190	5	227	5	264	23	301	53	338	101
154	-11	191	5	228	5	265	24	302	54	339	102
155	-11	192	5	229	6	266	25	303	56	340	104
156	-10	193	5	230	6	267	25	304	57		
157	-10	194	5	231	6	268	26	305	58		

APPENDIX

COOK

The term "cook" as used in this paper applies to the operation of cooking a digester by the Sulphite process. In brief, the digester is filled with chips and the interstices filled with cooking acid consisting of magnesium and calcium bisulphites dissolved in sulphurous acid. The time, temperature, and pressures are carefully regulated according to some predetermined plan until the lignin is dissolved to a greater or less extent from the chips leaving the undissolved cellulose to be blown from the digester with the liquid content.

COOKING CHARTS

It will be observed that the steam pressure and gauge pressure are on a different scale from the gas pressure and to this extent the chart is deceptive to the eye. To make these on the same scale the gauge pressure and steam pressure should be 14.7 pounds higher.

Just how this came to be plotted this way I do not know. However, the gas pressure is correct which, of course, is the main thing. The cooks have formed the habit of making charts this way and as a change of chart to a more scientific scale would not in the end enable them to make better cooks and would during the process of changing tend to have them make worse cooks, it has not been thought advisable to make it.

MENTAL FATIGUE

Morning Session:

- A to B tests made before first hour.
- C to D tests made after first hour.
- E to F tests made after two hours with recess of eight minutes between.
- E to G tests made after two hours without recess.
- H to I tests made after three hours with a recess of fifteen minutes after first and second hours.

H to K tests made after three hours with only one recess of fifteen minutes after second hour.

H to L tests made after three hours with no recess.

Afternoon Session:

M to N tests made before first hour.

O to P tests made after first hour.

R to S tests made after two hours with recesses of fifteen minutes toward the end of the first and second hours.

R to T tests made after two hours, no recess.

Now in explanation of the foregoing it must be distinctly understood that the recess periods are taken from the lesson time and devoted to recreation and, as is seen by the curves before you, is more than compensated for by the increased mental productivity of the children.

ORGANIZATION OF POWER OF HABIT

Elucidating the subject further I quote from Dr. Thompson's "Brain and Personality"

"As remarked before, no primary law or function in the nervous system is ever superseded by any later developments; and so, however great be the additions afterwards of brain centers or functions, yet the spinal nerve centers retain all their original prerogatives, quite as much in man as in any of the rest of the animal world. If, as remarked above, you wish to show the cunning of your right hand in any work of skill, or the fluency of your speech with your tongue, your designing and talking brain has to ask the spinal nerve centers for the muscles of the hand and for those of the tongue to direct those muscles to do the work for it.

Meanwhile this wonderful organizing power of afferent habit works out results in creating special functions or modes of working in the spinal cord which actually startle us with their close resemblance to what we are accustomed to regard as manifestations of design or purpose. Thus if a vigorous frog be suddenly decapitated with a sharp knife, and his headless body be put on a plate, it will forthwith jump up and assume on the plate a perfectly natural, if

not somewhat impertinent attitude. If now a small drop of acetic acid is applied on the frog's side, as soon as it begins to irritate the skin, the headless frog gravely and deliberately raises his hind leg and brings up his foot to scratch off the acid. If more acid be applied, he brings down the arm to help scratch the same spot; and if the irritation continues, he begins to lose balance by trying to bring up the other leg also until at last, as if the itching had become intolerable, he makes a most natural dive for the floor."

REVISED CONSTITUTION AND BY-LAWS OF BROWN COMPANY RELIEF ASSOCIATION

BY-LAWS

Article 1. Name and Object

Sec. 1. This Association shall be known as Brown Company Relief Association, for Mills and Departments connected therewith.

Sec. 2. Its object will be to insure its members against sickness and injury as specified below.

Sec. 3. In case of accident each member shall receive one-half the amount of his wages weekly while unable to work, but shall not receive this benefit for a longer period than twenty-six weeks. But no benefit will be allowed for the first week's disability.

Sec. 4. In case of sickness each member shall receive one-half the amount of his wages weekly during his disability, but shall not receive this benefit for a longer period than twelve weeks and no benefit will be allowed for the first week's sickness.

Sec. 5. No indemnity will be allowed for sickness until after thirty days from first assessment of a member, which assessment is payable when he signs the By-laws of the Association.

Sec. 6. Only one indemnity will be allowed for disability caused by combined sickness and accident.

Sec. 7. No indemnity will be allowed unless the member requires the regular attendance of a physician.

Article 2. Membership

Sec. 1. Membership of this Association shall be confined to the employees, male and female, of the Brown Company for mills and

Departments connected therewith, and any person in the employ of the company may become a member if the Executive Committee is satisfied and he or she is in ordinary good health.

Sec. 2. Each member shall sign the By-laws and thereby agree to support and be governed by them so long as he continues to be a member; and shall pay such sum of money as shall be determined by these laws.

Sec. 3. Any member leaving the employ of the Company or leaving the Association shall forfeit all assessments already paid in and shall not be entitled to any further benefits from the Association.

Sec. 4. Any member of this Association who shall put in a claim for disability and which upon investigation should prove to be fraudulent, shall be expelled and such expulsion shall act as a bar to further membership in this Association.

Sec. 5. Any member drawing pay from this Association for disability and who shall be found intoxicated, his pay shall cease from the time of such intoxication.

Sec. 6. Any member who is disabled by accident or sickness while in the employ of any individual, concern or such, other than the Brown Company shall not receive indemnity for said accident or sickness.

Article 3. Meetings and Elections

Sec. 1. An annual meeting for the election of officers and the transactions of general business shall be holden on the first Saturday of January each year. At all meetings 5 members shall constitute a quorum.

Sec. 2. Special meetings may be called by the President at his discretion, also by a majority of the Executive Committee, or by a written request of fifteen (15) members of the Association, presented to the Secretary, who shall issue a formal call setting forth the purpose of said meeting, and notice thereof shall be posted at least two days prior to date of said meeting and no business other than that specified in the call and notice shall be transacted except as otherwise authorized by these By-laws.

Sec. 3. The Executive Committee shall meet for the transaction of business on the first Tuesday of each month at 8 P.M., and at any other time upon request of the President or upon written request of three members of the Executive Committee. Notice of said

special meeting shall be given each member of the Committee at least twenty-four hours before the meeting shall be held.

Article 4. Officers and Their Duties

Sec. 1. The officers shall consist of President, Vice-president, Secretary, Treasurer and Executive Committee consisting of nine (9) members who shall be chosen separately by written or printed ballot annually, on the first Saturday of January at the annual meeting, and continue in office one year or until their successors are chosen. In case of resignation, disability or death of any officer a successor shall be elected by the members at a special meeting called for that purpose.

Sec. 2. The President and Vice-president shall be ex-officio members of the Executive Committee.

Sec. 3. The President shall preside at all meetings and enforce the laws, rules and regulations of the Association. He shall have the privilege of voting in case of a tie vote.

In the absence of the President the Vice-president shall act as President and perform the duties of said office.

Sec. 4. The Secretary shall keep a correct report of the minutes of each meeting and shall perform such other duties as the President may direct. He shall conduct the correspondence of the Association.

He shall post notices of all meetings of the Association in each department of the Company's Mills.

He shall draw all orders on the Treasury for money to be paid out and such orders must be countersigned by the President and one of the Executive Committee.

Sec. 5. The Treasurer shall collect from each member one-tenth (1-10) the amount of his indemnity every fourth pay day. He shall also collect all other moneys that may be due the Association.

Sec. 6. He shall deposit all moneys in the name of the Association in any bank selected by the Executive Committee.

He shall not be responsible for said funds in case the bank should fail.

Sec. 7. He shall pay out said funds only on orders drawn by the Secretary and approved by the President and one member of the Executive Committee.

Sec. 8. He shall keep a correct list of the members of the Asso-

ciation and the amount each one pays in during the year, and make an itemized report of the financial transactions of the Association and present same at the regular meeting in December of each year, showing percentage of loss and shall refund to each member such percentage of money remaining in treasury as shall be determined by the society.

Sec. 9. He shall give his bond with an approved security for the faithful performance of his duties in an amount fixed by the Executive Committee, which Committee shall also determine the amount to be paid him for the performance of his duties.

Sec. 10. The Executive Committee shall assist the President to enforce the By-Laws and rules of the Association. They shall pass upon all claims for indemnity referred to them and shall annually appoint a medical examiner.

They shall appoint annually one or more members of the Association to audit the Treasurer's accounts.

The Executive Committee shall have power to expel a member of this Association who causes bodily injury to another member through quarreling, and said member shall forfeit all he has paid in, and such expulsion shall act as a bar to further membership in this Association. The injured member will be paid his indemnity while suffering from said injuries, unless such time shall exceed twenty-six weeks, provided he shall be able to prove to the satisfaction of the Executive Committee that he was not a willing party to the quarrel in which he was injured.

Upon application the Executive Committee shall immediately furnish any sick or injured member with an indemnity application blank; which shall be filled out by the attending physician, and shall satisfy themselves as to the validity of said member's claim. This application must be forwarded to the Secretary without delay.

Article 5. Claims and Indemnities

Sec. 1. No claim for indemnity for sickness or injuries will be allowed to members of the Association that shall result from the following causes, viz.: the result from taking poison, injury caused by duelling or fighting, intentional self-inflicted injuries or where resulting from riot, voluntary exposure to unnecessary dangers, hazard or perilous adventure, or when injuries may have been received during state of intoxication.

Sec. 2. Any member of this Association who may be sick or injured shall without delay report the fact to some member of the Executive Committee who shall be governed by Article 4 Sec. 10. Members will be entitled to indemnity only from date that indemnity application blank duly filled out is received by the Executive Committee.

This does not conflict with Article 1 Secs. 3 and 4.

He shall make a thorough examination and shall report his findings to the Committee. The decision of the Medical Examiner shall be final in all cases.

Sec. 3. In case of death by accident of a member in good standing of this Association, his beneficiary shall be paid 26 weeks' indemnity.

In case of death by accident or sickness of a member in good standing of this Association, an extra assessment shall be collected from the members and the sum of fifty (\$50) dollars be paid to the person designated by the member in his certificate, for funeral expenses.

Sec. 4. In case there is money enough in the Treasury this extra assessment will not be levied.

Sec. 5. Any member having received the full twelve or twenty-six weeks' indemnity, as the case may be, and at some later date expires, from the same disability, cannot claim death indemnity.

Article 6. Amendments.

Sec. 1. These By-Laws may be altered or amended by a majority vote of the members present at an annual meeting, or a special meeting called for that purpose.

Article 7. Adoption of By-Laws

Sec. 1. These By-Laws shall go into effect as soon as adopted.

Statement.

As the regulations now stand a member cannot receive a weekly indemnity greater than one-half of his weekly pay based on a six-day rate. For this insurance he pays one-tenth (1-10) of the amount of the weekly indemnity to the Association every fourth pay day.

As this is a Mutual Association, at the end of the year each member receives as a dividend such a part of any money that may remain in the Treasury as the Society may vote to pay back to its members.

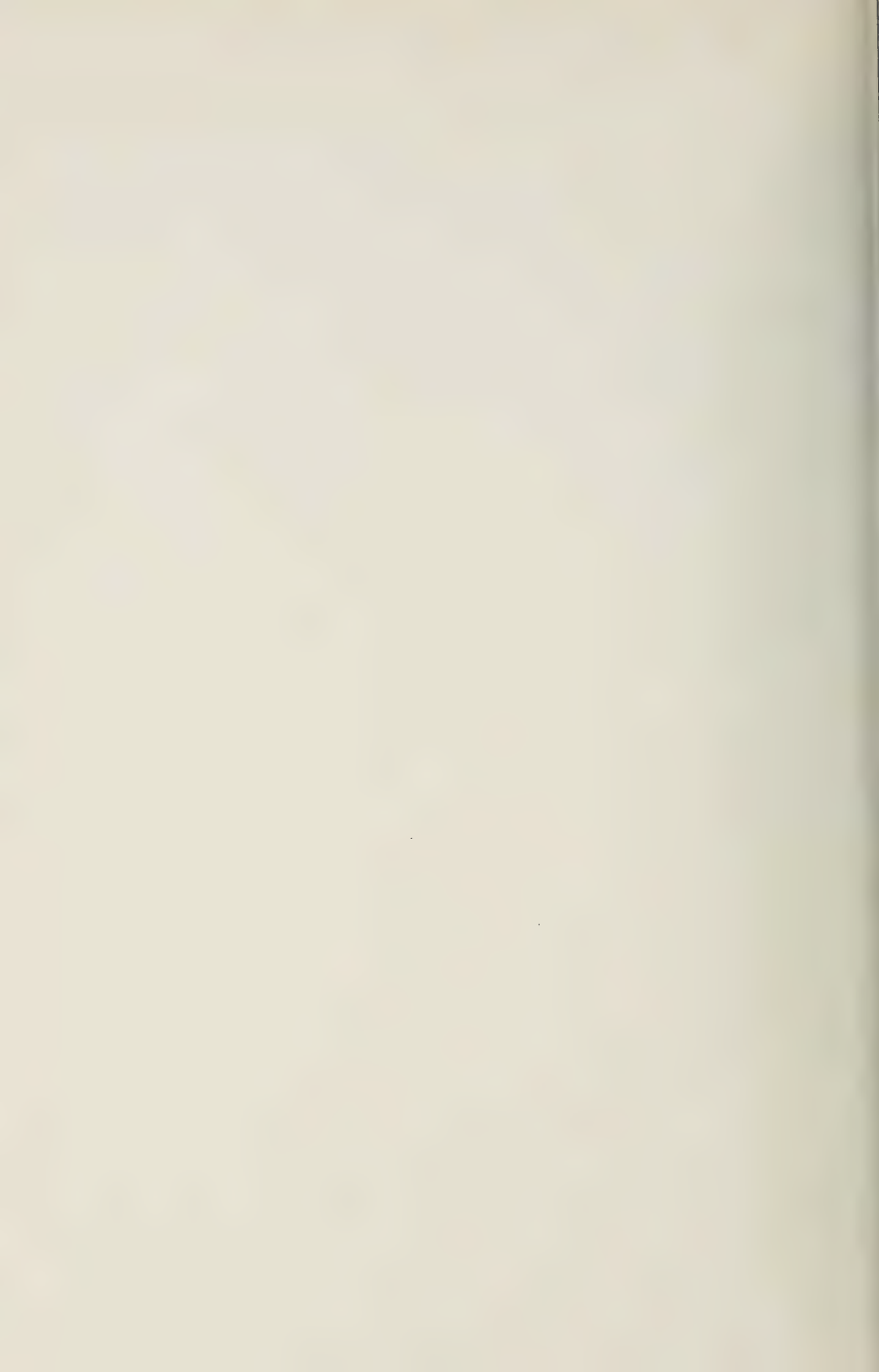
Officers

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Executive Committee

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Brown Company,
Berlin, N. H.



MAINTENANCE AND CONSTRUCTION ORGANIZATION OF SULPHITE MILL

By W. E. TAFT

Read at the Gorham and Berlin Meeting, June 19, 1918

The object of this paper is to give you a general idea of the methods we are using and an outline of the organization we employ, to carry on the varied work required to keep the plant in condition to turn out a daily average of 450 tons of highest quality bleach pulp.

Forces beyond our control, such as the general shortage of labor during the past year, have materially interfered with our plans for general improvement, and we must in a sense, apologize for many things you will see about the plant, assuring you that in ordinary times we would be able to present a better appearance than has been possible during the present strenuous state of affairs.

The policy of the company demands that the necessary new construction, as well as the general upkeep of the plant, shall be carried on by our own force, under the general direction and oversight of the engineering department.

Situated as we are in the heart of the mountains, far distant from any large labor center, the maintenance of the plant has made it necessary to meet our own special problems by the analysis of conditions peculiar to ourselves.

The engineering department is a distinct branch of the mill organization, having a separate field from the manufacturing department. Its duties are many, and on their proper performance depends the results possible to be obtained in the production out-put of the manufacturing department. It must provide the necessary new equipment of buildings and apparatus required by the growth of the business, it must keep all machinery in proper condition, be prepared with spare parts to replace the natural wear and tear of service, provide sufficient steam and electric power to keep 800 cords of wood turning into pulp every twenty-four hours, and be ready at all hours of the day or

night to cope with any troubles which threaten the production of the plant.

The organization is as follows:

The engineer of the department, who receives his general orders from the superintendent, and is responsible to him for the performance of all work. It is subdivided into the office branch, comprising the drafting and engineering rooms with assistants, labor clerk, stock clerk, and errand boys; and the mill branch consisting of the power plants and the various mill crews headed by the master mechanic.

This plan of operation places the department in the dual role of contractor and engineer, hiring and training its own labor force, as well as solving the various engineering problems that constantly arise.

We are indeed at a disadvantage, compared with the ordinary contractor, who is able to carry out his contract knowing that he will require a specified number of workmen, whose energies will be confined exclusively to one undertaking and will not be subjected to the conflicting demands occasioned by breakdowns in the plant or the thousand and one reasons that may require sudden changes in the amount of labor that can be held available for one purpose.

We must have in our organization men of many trades prepared to cope with any emergency that may arise, ready to jump in day or night at any job required to prevent or overcome breakdowns which would interfere with the production of the plant.

Our force contains millwrights, carpenters, pipers, plumbers, tinsmiths, leadburners, teamsters, boiler makers, painters, electricians, blacksmiths, refrigerating men, draftsmen, machinists, as well as many ordinary and semi-skilled laborers.

We cannot go into an outside labor market for men of these trades, when there is a sudden call. They must be ready for use at any time in the twenty-four hours. It is, therefore, requisite that we not only have men on hand, but that we so plan our work that they may be kept busily employed from day to day.

At the time we started to develop our present system of handling labor, we were running under the old fashioned routine which, I venture to say, is still carried on in seventy-five out of one hundred mills in this country. Briefly, this consisted of the various workmen to the number of one hundred or more gathering at 7 o'clock in the work shop and patiently waiting for the master mechanic to tell them what to do. Naturally in trying to lay out work for a large number of men, he was placed in a false position, unable to plan the

work intelligently, sending too many men on one job, and too few on another, contradicting his orders and wasting the best part of an hour for both himself and his men before he could get the day's work started.

This antiquated and wasteful method of handling men was discarded some time ago and results have shown it possible to obtain more and better work from the men at a less unit cost and it has been done in such a way that the men take a much greater interest in the work and feel that they are considered an essential part of the organization.

All work is studied and planned for in the office branch before orders are given for its execution. Proper plans are made for new construction work in the drafting room, materials are then requisitioned by the stock clerk and engineer's assistant, the orders placed are followed up until delivered and notification is made that all is in readiness to start work.

In the general repair work of the plant it is not always possible to make drawings that might be desirable, on account of the delay involved, so that we find it somewhat necessary to plan in part as the work progresses.

We have in the office a labor clerk who receives all requests for work desired. Manufacturing department heads and foremen are expected to notify the clerk either by telephone or personally, regarding any work they may require and in order to have it considered for the following day it must be submitted before 4 P.M.

One of the hardest functions of the department is to decide who shall have first preference as to the work desired, each department naturally considering that their work is of the most importance. All the requests are made out by the clerk in the form of orders, written with manifold copies having a distinctive color for each class of labor, with a notation showing to what the work is to be charged. They are then submitted to the engineer or assistant for approval who determines what shall be carried on the following day. At 4 P.M. the master mechanic meets the labor clerk in the office, and then decides who shall do the work, as we do not ordinarily wish to dictate to him in the selection of the individual men. He details the different men needed, designating the foremen, who may have charge of more than one job, and also the leaders for individual jobs, any crew of two or more having a leader.

The clerk then makes duplicate lists of the jobs, with men detailed

for the following day and the master mechanic has time to give his foremen any special orders that may be required before he leaves at night.

At 7 A.M. the master mechanic receives his list with any men who may be out noted, and then is prepared to supply vacancies promptly if necessary. Copies of the schedule are also given to the superintendent and engineer. This procedure enable the master mechanic to know what jobs he is expected to carry on, and it is also necessary that each individual man should be informed regarding his duties. A slip is made out in the office for each man, briefly stating what job he is to start on at 7 A.M. and who will be his foreman or leader; foremen and leaders slips designating jobs and the men they are to have. These slips are attached during the night to the men's time cards, so that when they take their cards in the morning they know just where they are to work, with whom they are to work, and they are expected to take their tools and proceed to their job without any delay in the shop. The saving of time over the old method has much more than paid for the necessary clerical work involved.

To avoid delays by this system it is a standing order that any work necessary to prevent a breakdown, and which cannot wait a half hour, shall be called a rush order and sent directly to the master mechanic.

Foremen and leaders on jobs are expected to supply themselves with minor materials needed on the work by telephoning to the mill office from which point a clerk sends an order to the storehouse; it being the duty of the storekeeper to send these supplies direct to the job by a boy, thus avoiding high priced men being used as messengers. A pneumatic tube system between the mill office and storehouse eliminates any delay. When a job is nearly completed the foreman notifies the master mechanic. By means of his boy who travels with him, he is in touch with the office and sends him for additional orders as required, the boy turning in all completed orders to labor clerk with the time finished noted on order.

The labor clerk has in his office a wall board on which are hung copies of all orders on which work is being carried on, tags showing the men on job, being hung under the orders, the board as a whole showing all work under way and the distribution of men. From this board all costs of each job for labor are computed and with duplicate material slips from storehouse, the complete cost of job is known.

With a plant running twenty-four hours daily it is necessary that

much repair work be done on Sunday. To cover this a form is provided for Sunday work. Department heads are expected to turn in these forms daily during the week; as early as possible, and not later than 4 P.M. Friday, thus giving time to provide necessary material. On Friday a general meeting of superintendent and department heads is held, at which time these Sunday jobs are considered and a decision made as to the most important things which must be done, the men for the work being detailed on Saturday.

It is not considered just or efficient to allow the men to work seven days a week, so every day-man who works on Sunday is entitled to and obliged to take a day off during the week of one-half of the time he worked, he receiving his regular pay for the lay-off period.

In order to handle this properly we find it best to have a graphic method showing the crews, and you will find in the office a wall board having a tag for each man and spaces for different days of the week. On Monday these tags are shifted about to show the men who are entitled to time off, and they are then arranged so that certain men, as they can best be spared, are slated for the different days, and the men who are to substitute on special work are designated.

We have found that the average man is very wasteful of materials, not so much intentionally, as because he has never been given the opportunity to realize that even little things, such as a bolt, in the aggregate may mean a large amount. It was decided to attempt an improvement by bringing the matter to the individual's attention, by appealing to his desire to make a good showing and letting him see the cost in dollars and cents. A daily form was gotten out showing the cost of each job from day to day for labor, and a list of materials used, with their cost in dollars and cents, even the minor materials being priced. The results have been good and we find men on their own initiative using second hand materials and cutting costs in various ways. We often have to decide disputes between foremen and storekeeper as to whether he has not charged them too much for their supplies.

The safety movement receives careful recognition in our organization and is carried on to a great extent by the men themselves. Every month a man is selected from each department to serve for three months so that departments are always represented by three men, the oldest of these becoming in turn the chairman, and the chairmen of all departments constituting the general safety committee.

Once a month the committee is given a day to make a general

tour of the plant, taking with them as secretary the safety foreman, who notes down any suggestion they make. They are free to and expected to criticize any appliances or methods of doing work that they may consider dangerous. Their suggestions are tabulated in the office and carefully considered. We find them to be nearly always good and proper suggestions and the safety foreman receives orders to make the necessary changes with his crew.

The department committee men are notified immediately of all accidents and are expected to personally investigate and make report of changes required. As a result of this we have reduced serious accidents at least 75% and now find the great majority are due to the human element of carelessness and not avoidable by change of apparatus. We also find that the question of nationality is closely related to the percentage of accidents and should be considered in the adaptation of men to certain classes of work.

Every piece of apparatus in the mill has a distinctive name, by which it can readily be identified. By means of a very comprehensive card system in the office a complete record is kept of the individual cost of maintenance of apparatus and by summary cards we are enabled to arrive at the general cost of maintaining each department, monthly cost sheets being made up for the department heads, enabling them to analyze the actual cost and to make suggestions to the engineering branch regarding apparatus which shows by the high up-keep cost to be in need of improvement. Graphic records are kept of all the most important supplies such as felts, belts, wires, ropes, oils and grease, so that any tendency to increased costs can be investigated.

We have about five hundred belt drives in use, each of which has its name. A record is kept of belt showing its width, ply, length, speed, and horse power, with the cost per day for its up-keep. A belt man makes all repairs to belts and renders a daily report of their condition. Our belts formerly cost us 21 cents per ton of pulp. Six months after putting on this man the cost was reduced to less than 10 cents. For 1917, although belting is much more expensive per foot, the cost has dropped to $5\frac{1}{4}$ cents per ton.

We test supplies such as hose, belts, or packings for efficiency by trial first on a small scale, keeping record of their value to us on the cost per day basis.

In the curve room of our office you will find a very comprehensive set of graphic charts, covering all the important operations of manu-

facturing and maintenance. The limit of this paper does not permit me to go into this subject in detail, as we have about ninety charts in use covering the daily costs of handling our raw materials, such as coal, lime, sulphur, and wood, as well as the different elements which enter into our manufacturing processes, such as acid strength, length of cooks, bleach per cent, strength and cleanliness of fibre.

Daily charts are also made up showing the efficiency of our different foremen in relation to the cost, quantity and quality of production. These foremen are rated by a certain standard and their daily percentage is placed on a mill bulletin.

We have in process of construction a boiler and turbine plant which will have a normal capacity of 5000 H.P. and a 15,000 overload capacity. The boiler plant will contain five units, three of which are now in service, it being so arranged that each boiler has its own economizer with forced and induced draft fans, any of which can be cut in or out of service independently.

The equipment consists of mechanical stokers designed to burn the poorer grades of coal, such as culm refuse, as well as No. 1 birds-eye. In order to obtain high efficiency with this fuel, it is necessary to carry a balanced draft in the furnaces and this is taken care of by an automatic electric control of our own design, which is so arranged as to vary the fan speeds and hold a balance without the attention of the firemen. Auxiliary apparatus includes the latest type of turbine driven pumps and fans.

In connection with the plant is a control or instrument room, containing recording steam flow meters, CO₂ recorders, pressure and draft gages, pyrometers for furnace and flue gas temperatures, and feed water thermometers, each boiler having its own set of instruments. An observer, who is independent of the boiler room crew, is on duty in this room on each shift. A standard for desired conditions of control has been established, this standard being purposely made a little more rigid than what we expect to obtain. A certain minimum below the standard is allowed. The observer at stated intervals notes the actual conditions and enters them on his log sheet. Should he find any conditions, such as furnace temperature, below the minimum, he notifies the head fireman.

The necessary measures for improving the conditions are taken by the head fireman, as the observer is not responsible for the results obtained.

The general average of conditions is tabulated for each shift and

the daily results are published, together with the relative efficiency of the different crews.

The turbine plant will contain three machines having a capacity of 10,000 H.P. and will be so equipped as to furnish power when required to any of the different mills of the company.

At the present time we are working under war conditions at a great disadvantage. Many of our best men have been taken and our labor, though highly paid, is necessarily less progressive as a whole, but we find, nevertheless, that in spite of the enormous increase of material cost, our system and organization has enabled us to keep up the plant at a less unit cost than we could when working under the old conditions, where the absolute lack of control tended to prevent any progress towards better efficiency.

DISCUSSION

Dr. LANGMUIR: In connection with Dr. Moore's statement as to the benefit system for their employees, I might state our own experience, at the plant of Marx & Rawolle, Inc., glycerin manufacturers in New York, in order to emphasize the cheapness of this beneficial work, which supports the men during any sickness, or loss of time through injury. We were very much surprised to see how cheaply this work could be carried on.

The firm started in four years ago with the contribution of \$500.00 to the sick fund; and the men contributed to that fund, each week, 10c a person, paying a sick benefit of \$10.00 a week for a period of eight weeks, and a death benefit of \$50.00; and we were very much surprised and gratified to learn that for so small an expense per man that we could maintain that system and actually increase the surplus. The balance now, after four years' experience, amounts to \$700.00; so that if any of you have plants where the workmen don't have beneficial associations, you might find our experience of value. We have not contributed ourselves, beyond making the initial payment of \$500.00 for safety reserve.

The VICE-PRESIDENT: I would like to ask Mr. Taft what kind of recorders he uses—finds best for different purposes, and how much their upkeep amounts to?

Mr. TAFT: We use a great many Taylor Instruments in our Boiler House and find them satisfactory in most respects. We

also have many Bristol Instruments. One fault with the Taylor Instruments so far, is that they have not been able to furnish couples to give a proper record of the furnace temperatures. With the instruments they furnish, the protecting tubes of the platinum couples have not stood up against the high temperatures in the furnace. Their claim was that they would stand 3000° F., but the tubes melted at about 2700° , and on account of this trouble we have not been able to get proper records of our furnaces. We should be very glad to find something that will stand against the high heat.

The VICE-PRESIDENT: What kind of CO_2 recorders do you use?

Mr. TAFT: We have the Hayes and Uehling. The Uehling, I find, is a little better adapted to our conditions, but the other is very satisfactory. We have an observer on each tour to keep the instruments in order, but they require very little attention.

The VICE-PRESIDENT: And the SO_2 ?

Mr. TAFT: The SO_2 recorder is one of our own get-up of which Mr. Moore is the originator.

The VICE-PRESIDENT: Is the SO_2 recorder on the market or is it your own design?

Mr. TAFT: No.

The VICE-PRESIDENT: Is there any further discussion?

Mr. DILL: I would like to ask Mr. Taft what kind of steam flow recorders he uses?

Mr. TAFT: The General Electric Flow Meter. We have the largest type of instrument they make, with a range of 3000 Horse Power. Our battery of boilers so far installed, are 1000 unit Heine Boilers. The only trouble we have had with the General Electric meter, is that it is not quite large enough for our peak load as we carry at times over 3000 H.P. on each of these units. The instrument has given us no trouble.

Mr. DILL: Have you got any other make of meter?

Mr. TAFT: No.

Mr. DILL: I would like also to say, in line with what Dr. Wagner has said, that I do appreciate Dr. Moore's paper very much, and would gladly come all the way from New York if his were the only paper to be presented. I was particularly interested in what he has said concerning the welfare work at the mill, and would like to ask two questions: first, who makes the physical examination of the men that he referred to at the end of the paper; and if he doesn't wish to say publicly, perhaps he will tell me privately a little later on;

and, in the second place, while the men are attending rehearsals for the minstrel show, is that done voluntarily, on their own time, in the business hours? Does the company bring any pressure to bear to make them attend the rehearsals?

Mr. MOORE: This is done by the Life Extension Institute of New York, who send their man up here and examine by departments. Later it is expected to group the whole mill and take the physical examination; and it takes about forty-five minutes to an hour to give them a complete physical examination. You go into their room while the examination takes place, you will see instruments enough there to make you think you are in a laboratory; and you get a complete physical examination; and this report is sent on to New York and reported. I forget just the name of the man that was sent here;—perhaps, Mr. Van Arsdale, can you tell us? I can find it out for you: it is the Life Extension Institute of New York.

In relation to the minstrel show, this is the men's own affair. There is absolutely no compulsion on the subject, whatsoever: in fact, it is the heads of the departments that take a back seat to the mill men there. They are sidetracked; and the mill men run it, just the same as they run their insurance organization. They have their own officers and everything else; and the whole thing is an absolutely democratic thing; and whereas the company does often-times furnish them materials if they ask for it—what I mean to say is physical materials, and do things of that sort—the company absolutely has nothing to do with it.

For instance, you are going to hear this minstrel show Thursday night. I went to Mr. Brown and I said: "What do you think of giving an illustration of what the men do?" He said: "That is up to the men themselves—if they want to do it, they can do it; if they don't want to do it, that is all right." The men do it themselves; the company have absolutely nothing to say. No pressure is exerted; absolutely no influence at all is exerted on the subject.

The VICE-PRESIDENT: The question of giving credit to the workmen for their ideas, which Mr. Moore brought up and which Dr. Wagner also touched upon, I think is very important. We do it at the Merrimac Chemical Company's plant in the following manner. We have a monthly meeting of foremen and sub-foremen at which we give them supper; and then each is called upon to give a report regarding his work; and is asked to make any suggestions he can

think of regarding any improvements that would benefit the company. Records are kept of those suggestions. In this way a permanent record is kept of the suggestions and who initiates them; thus the credit, if any, goes where it belongs.

We have received a good many valuable suggestions in this way. At these meetings, we also have a report of the safety committee of the preceding month; this committee consists of a permanent safety committee made up of the master mechanic, the chief engineer and the head carpenter; and a sub-committee, changing each month, made up of five workmen taken at random from the different departments. They give up a day once a month to making a thorough examination of the entire plant, with an extra compensation of 25c, so as to make it attractive to them to get on the committee. They go around and examine everything and make their report to the permanent committee, then the joint report of the two is turned in at the monthly foremen's meeting, but after it has been approved by the Works Manager. For the next month, a new lot of five active workmen are put in. By this means, in the course of a year, we interest sixty men scattered throughout our plant in accident prevention work. The plan has been in force for four years and works exceedingly well.

Mr. VORCE: I wish to emphasize what Mr. Howard has said in connection with Committee Work. It is always hard to get Foremen who will work together, without friction. This was illustrated in an organization which I had the pleasure of developing. I found that, while each Foreman was trying to conduct his own department so far as he could, for the benefit of the Company, he, naturally, considered his own department of more importance than any other, with the result that there was a lack of co-ordination, and frequent disputes among the men. To overcome this, we called a meeting of all the Foremen, twice a month, at which meeting differences of opinion could be discussed, work planned, and material arranged for. We organized ourselves into committees:—Safety, Fire Protection, Yard Appearance, etc. We also instituted a Question Box, and a premium arrangement for the best idea of improvement or economy, proposed during the year, with a committee to make the awards. In these meetings it was possible for the Superintendent to trace any delay in construction, or operation work through the different Foremen involved, at once, without having to

interview them separately, as formerly. The result was a harmonizing of ideas, and endeavor, which improved the work as a whole.

What Mr. Moore has given us to-day, is simply an exemplification of the fact that we, as a people, are beginning to realize more and more, even from a selfish standpoint, if you wish to put it that way, that we are our Brothers' Keepers, and every step which is taken in this direction is not only a step in advance from a philanthropic attitude, but, as has been shown, a step in advance for the Stock Holder.

THE MANUFACTURE OF ALCOHOL FROM SULPHITE WASTE LIQUOR

By **RALPH H. McKEE**

Read at the Gorham and Berlin Meeting, June 21, 1918

I wish to present to you today a new method * of obtaining alcohol from the waste liquor discarded by sulphite pulp mills and from similar sugar containing liquors. This method is unlike the methods which have been commercially used previously, in that it does not require neutralization of the acid sulphite liquor. The common understanding has been that sulphur dioxide and sulphites are yeast poisons. Yeast organisms require the presence of oxygen for their growth, and I have found that the materials just mentioned are not yeast poisons except to the extent that they absorb the oxygen present in the solution and hence bring about oxygen starvation of the yeast. The simplest method of meeting the oxygen requirement of the yeast is to cause air to bubble through the solution during the fermentation period. When this is done every variety of yeast which I have tried seems to grow perfectly satisfactorily in the sulphite waste liquor. This you will note, is in direct contrast to the neutralization process where a yeast specially acclimated to the sulphite liquor is necessary for fermentation. In the old process sometimes air is blown through the liquor during the neutralization process, but this is scarcely sufficient to meet the yeast requirements.

The method of carrying out the process on a commercial scale is as follows: The hot sulphite waste liquor is introduced at the top of a tower, and air with a little steam at the bottom. By this treatment a portion of the dissolved sulphur dioxide is removed. The resulting liquor, still hot, is then run through a second tower against a current of air. This cools the liquor to the fermenting temperature, 90° F., and it is now ready to be put into the fermenting tanks. Yeast and proper yeast foods, if desired, are added and a slow current of air run

* Patents granted in the United States and abroad.

in at the bottom of the tank. This air is simply to keep the solution saturated with air during the fermenting process and is continued throughout the entire fermenting period. The resulting fermented liquor is then distilled, preferably in a copper still or in a cast iron still with enameled lining. Either continuous or batch stills may be used. My personal preference is for a continuous copper still for the beer, and that the resulting high wines obtained from the beer still be redistilled, using a batch still, with the addition of a little soda ash to neutralize whatever sulphur dioxide or other acids have distilled over with the high wines. The resulting product is an alcohol of the same grade and character as that made from sulphite waste liquor by the neutralization processes. It carries some methyl alcohol and consequently would go primarily for the manufacture of denatured alcohol.

It is the common belief of those unacquainted with the industry that the alcohol, obtained when sulphite waste liquor is neutralized and fermented, does not carry sulphur dioxide into the still column. This is not correct. It is necessary in such processes to remove sulphur dioxide from the alcohol by the use of soda ash or other alkali.

The present process gives yields fully equal to those obtained by the neutralization processes. The advantages of the present process over the neutralization processes that have been used are:

- (1) The saving in equipment installation.
- (2) The saving in lime for neutralization which must be purchased by all mills excepting those which have a soda or kraft mill in their vicinity, the lime sludge from the soda or kraft mills serving in place of slaked lime.
- (3) The saving of the labor and expense involved in neutralization and filtration; and, most important,
- (4) The fact that the method gives uniform yields of alcohol. It is not commonly appreciated that neutralization processes are found to give erratic yields. For example, in one plant the yield varies, apparently without cause, from 0.2 per cent to 0.6 per cent.

I have carried out some 150 fermentations using sulphite liquor from more than a dozen mills. The yields of alcohol vary with the character of the cook, a long cook such as is used for the manufacture of writing paper giving the highest yield, approximately 1.3 per cent absolute alcohol, as compared with the volume of the sulphite liquor taken, to a minimum of 0.50 per cent in the case of sulphite mills making pulp such as is used to mix with ground wood in the manu-

facture of news paper. The average is about 0.90 per cent; i.e., about 18 gallons absolute alcohol per ton of pulp made.

Sweden and Germany have about 30 plants making alcohol from sulphite waste liquor, the United States 2 plants. All of these use the neutralization processes. The United States has 95 sulphite mills making an aggregate of about 1,400,000 tons sulphite pulp a year

COLUMBIA UNIVERSITY,
NEW YORK CITY.

DISCUSSION

The VICE-PRESIDENT: The paper is now open for discussion.

Mr. CHUTE: I can confirm what Dr. McKee has said about the advantage of adding air to the sulphite waste liquor. In 1912 a plant was constructed in the works of the International Paper Company at Palmer, New York, with a special apparatus for producing yeast rather than alcohol. One of the features of the fermentation process used there was the continuous addition of air through a (perforated) pipe at the bottom of the fermentation tanks; and the development of yeast was very good, and the fermentation was quite perfect. They did not make alcohol from this, the purpose being to make yeast, which they made successfully; and that yeast was used in making bread. The process was not financially profitable, however. A Mr. Haaglund, a Swede, has written something on that subject, which has been translated lately into some Canadian paper trade journals. He mentions the fact that when the yeast begins to work in the sulphite waste liquor it becomes pale, owing to the oxygen disappearing; and he also recommends that air be blown through. And it is undoubtedly advantageous to add air in fermenting sulphite waste liquor.

I believe, however, everyone has thought that the waste sulphite liquor should be partially, or wholly—perhaps wholly neutralized before it was fermented; and I feel sure that most of the sulphite waste must have yeast foods added, because they lack both enough ammonia or nitrogen, and phosphoric acid. That, however, is not a matter of any great difficulty.

It is also true, as Mr. McKee said, that the alcohol coming off should be neutralized on redistillation. Ekstrom has patented several methods of neutralization of the alcohol by treating the vapors with

alkalis. I haven't the patents with me; but I have seen them lately. The question of the financial profit of distilling this sulphite waste liquor will depend very largely on getting an economical still for the treatment of the primary liquor, owing to its extremely small quantity of alcohol; and, in my opinion, a very high, many-chambered so-called beer still would be the best adapted for this purpose; because it is the way in which the alcohol may be removed by using the least steam; and the great expense of the process will always be in treating this enormous quantity of waste liquor to obtain a very small quantity of alcohol. This latter treatment of the crude alcohol may be very advantageously performed in a column still and refined to a high grade; because there will be a very small quantity of alcohol, and economy of distillation is not so important there; and I would further say that I feel that Dr. McKee has here shown a field for the production of a large quantity of alcohol now going to waste, and that it may be made profitable both under the present war conditions and under normal conditions.

Mr. MOORE: I would like to ask Dr. McKee if he has tried any experiments on using ammonium chlorid as a nutrient to furnish the nitrogen for his acids. I understand that some experiments have been tried at the Mellon Institute in which ammonium chlorid with a certain amount of calcium salts have been added to furnish the nutriment. It is claimed that only one-twentieth as much yeast is required. I have heard that the Ward Baking Company are using ammonium chlorid and calcium sulphate to ferment bread. Of course, they are not after alcohol: they are using it for raising bread; and they claim that it cuts down the yeast to one-twentieth of that formerly used. Is there anybody who can give any information on that subject?

Mr. McKEE: That work was done by Hoffman at the Mellon Institute. The yeast production is correct: it is approximately one-twentieth. So far as yeast foods are concerned, the cheapest is to draw off after the fermentation and hydrolyze that yeast as food for the next batch. For that hydrolysis two minutes 50° C. will serve. Ammonium phosphate will serve—I mean ammonia salts and phosphates—for sulphite waste liquors; though it is not the cheapest way to do it. Yeast settles out nicely and quickly by hydrolysis; the bodies of the past serve for food for the new generation.

Mr. MOORE: What I have reference to—I, of course, understand the hydrolyzing of the yeast; but in any large operation you have

got certain mechanical losses, probably depending upon the product you are fermenting; and I wanted to know simply whether that statement which was rumored about of—that they could start out to build up your first yeast, to build it out of your ammonium phosphate, or any of those amines—I wanted to know whether what I had heard was rumor or true.

Mr. CHUTE: I think it is. There is no question but what the dead yeast will act as a fertilizer for the new yeast, yeast being a plant and, like all plants, it can use most any organic matter as a fertilizer. It is quite common, or was quite common, in the manufacture of whiskey in the United States from corn and rye and from molasses, to slop back, throwing back a considerable portion of the slop into the new batch; one of the reasons of which was that the dead yeast furnished the food for the succeeding batch to be fermented; and there is no doubt but what the devitalizing of the yeast by hydrolysis, or any method of killing it, will furnish a satisfactory yeast fertilizer.

With regard to the use of lime salts and ammonium salts, it has been customary to use ammonium sulphate because it is the cheapest; but other ammonium salts could still be used as a fertilizer without any trouble; and those who make beer know that calcium sulphate in the water is a good thing to promote fermentation; in fact, the waters at Burton-on-Trent, from which the celebrated Bass ale is made, are saturated with calcium sulphate; and among the brewing trade there is offered "Burtonizing salts," which are merely salts to produce a saturated solution of sulphate of calcium in the beer breweries; so that calcium sulphate seems to have a beneficial effect on fermentation, for beer at least, and presumably for the manufacture of distilled liquors.

Mr. MOORE: I talked about this other proposition in relation to the United States government work, and the man I was talking to claimed that any calcium salt was as good as calcium sulphate. I would like to ask these gentlemen if they have any information on this question, or whether it is still on a theoretical basis.

Mr. CHUTE: I have no information on any calcium salt other than calcium sulphate; but it is self-evident that you would have calcium sulphate in any sulphite waste liquor. So that you would have a saturated solution of calcium sulphate in any case in the sulphite waste.

Mr. MCKEE: I can confirm what Mr. Chute said, so far as vinegar bacteria are concerned; and that is, that it is the ions that serve

as food. It does not matter in what form the calcium ion is provided nor the ammonium ion. Whether it is the same in the case of yeast or not, I do not know; but I presume that it would be the same at least in the dilute solutions used customarily.

The VICE-PRESIDENT: Any further discussion?

WILLIAM GARRIGUES: I would like to ask Mr. McKee if he knows that there is any glycerin produced in that fermentation from sulphite liquor.

Mr. McKEE: I do not know that there is. Apparently there are just the same things produced in sulphite liquor fermentation as are customarily produced in grain fermentation; such as aldehydes, and, of course, ethyl alcohol and amyl alcohol, or fusel-oil. The fusel-oil production is very much smaller than in grain fermentation.

I would like to raise a question regarding one statement made by Mr. Chute as to the cost of distillation of alcohol from the dilute solutions. At first sight it looks as if you are going to boil and handle our whole volume of solution; but that is not where the heat is used. The heat is used on the vapors which distil over; so that it becomes the latent heat of the alcohol distilled over which is the dominant factor, not the sensible heat of the volume of liquor used; in other words, I don't think if you calculate out the amount of heat required or amount of steam used, that it will be 5 per cent more, whether you distil a 1 per cent alcohol solution or a 20 per cent alcohol solution. That is, if you distil over 100,000 gallons of 1 per cent solution, or 5000 gallons of a 20 per cent solution, your amount of heat used is approximately the same if ordinary heat transfer apparatus is used. The amount of steam used is essentially dependent upon the amount of alcohol distilled off, not the volume of your liquor used.

Mr. CHUTE: I want to call attention to the fact that it depends a good deal on what you expect to do with the slop, and whether the sensible heat in the slop is going to be utilized further. Of course, by a counter-current system you can, by enough refinements—addition of enough copper for the heat transformation or transference—cut the slop temperature down to almost the temperature of the entering beer, as it is called in America; but, assuming that the fermented liquor is at 80° F, you, of course, have to raise it to the boiling-point, and you have put in about 132° of heat; assuming the latent heat of vaporization to steam is 1000, which is about right, you see that the amount of steam necessary to furnish that heat to heat up 100 gallons

through that range of temperature, would be equivalent to 13.2 per cent of the volume you are heating up.

Now, that is the minimum amount of heat you can use, unless you have some kind of heat transference. You can, of course, by elaborate heat exchanges, cool down your slop; but the column-still, divided into a great number of chambers, will distil off a very concentrated alcohol, while, at the same time, exhausting the alcohol completely from the bottom. No kettle still, no pot still will do anything of the kind: you must distil off a very large fraction of the liquor to get out the last possible trace of alcohol. If you are working with $\frac{1}{2}$ per cent alcohol, you have got to do a great deal of boiling before you get off the last trace; and unless you do that, you will not get a very complete recovery of alcohol, starting with such a low-grade stuff; therefore, I think that I am justified in saying that you should have a very high column, with a large number of chambers, to get economical distillation of a very dilute solution. In fact, all of the distilleries in the United States, up to the present time—and the distillation industry is quite old—all of the distilleries who have made any attempt whatever to make economical alcohol have adopted that system as a result of experience.

Mr. MOORE: Mr. Chute advances the first topic which I was going to take up; but I would like to ask Mr. McKee about the other; he mentioned the amyl alcohol as one of the impurities; but I would like to ask him about the alcohol which he gets from sulphite with reference to impurities.

Mr. McKEE: On the small lots worked with, the amount was so small that no furfural or fusel oil tests were made. As I understand it, in the Ekstrom process, which is the only one that has been used on the large quantities, they do have some fusel oil formation; and I presume this new process would have the same.

Dr. WAGNER: I would like to answer Dr. Moore's question, possibly in a different way. In the alcohol which is made by hydrolized wood waste, especially soft wood, yellow pine, there is only a trace of furfural; so that I might answer that in that way.

Mr. MOORE: I was asking especially about the alcohol made from sulphite waste liquor, the products which you get from treating wood and hydrolizing wood are entirely different. The alcohol is entirely different from what you get in the actual sulphite liquor in fermenting that; and while I am more or less familiar with the straight hydrolysis of wood by different processes, I am not familiar with the

product obtained by fermenting waste liquor; and it seemed to me that there must, owing to the nature of the process, be at least more than a trace of furfural in the SO_2 , where the SO_2 is used to cook chips; and I was interested to know what the information was on the subject.

Mr. CHUTE: I would like to ask a question: this is a good time to do it. The process first introduced into this country for making grain alcohol from wood on a large scale, I think involved the treatment of chipped wood with sulphurous acid gas. We have seen, to-day, the treatment of wood with sulphurous acid gas. These are two processes which are seemingly very similar to each other: the Classon process, as I remember the patents, and, later, the Ewing-Tomlinson processes. Both claim the treatment of wood chips with sulphurous acid, with the idea of getting the maximum amount of alcohol. You treat your wood in the paper business with sulphurous acid, and get the minimum amount of alcohol.

As Dr. Wagner has a great deal of experience in the manufacture of alcohol from wood, getting the maximum amount, and there are a number here who have had a great deal of experience in treating wood to make sulphite fibre, I should like to find out what the difference in treatment is that makes such a great difference in the sugar content of the sulphite portion.

The VICE-PRESIDENT: Are you asking this question of Dr. Wagner?

Mr. CHUTE: I should like Dr. Wagner to answer as much as he can or will; and I would be glad to hear from anybody else who can tell me anything about it.

Dr. WAGNER: I fear I shall have to plead ignorance; because I have not made that a study. It is an interesting question, that ought to be looked into and cleared up.

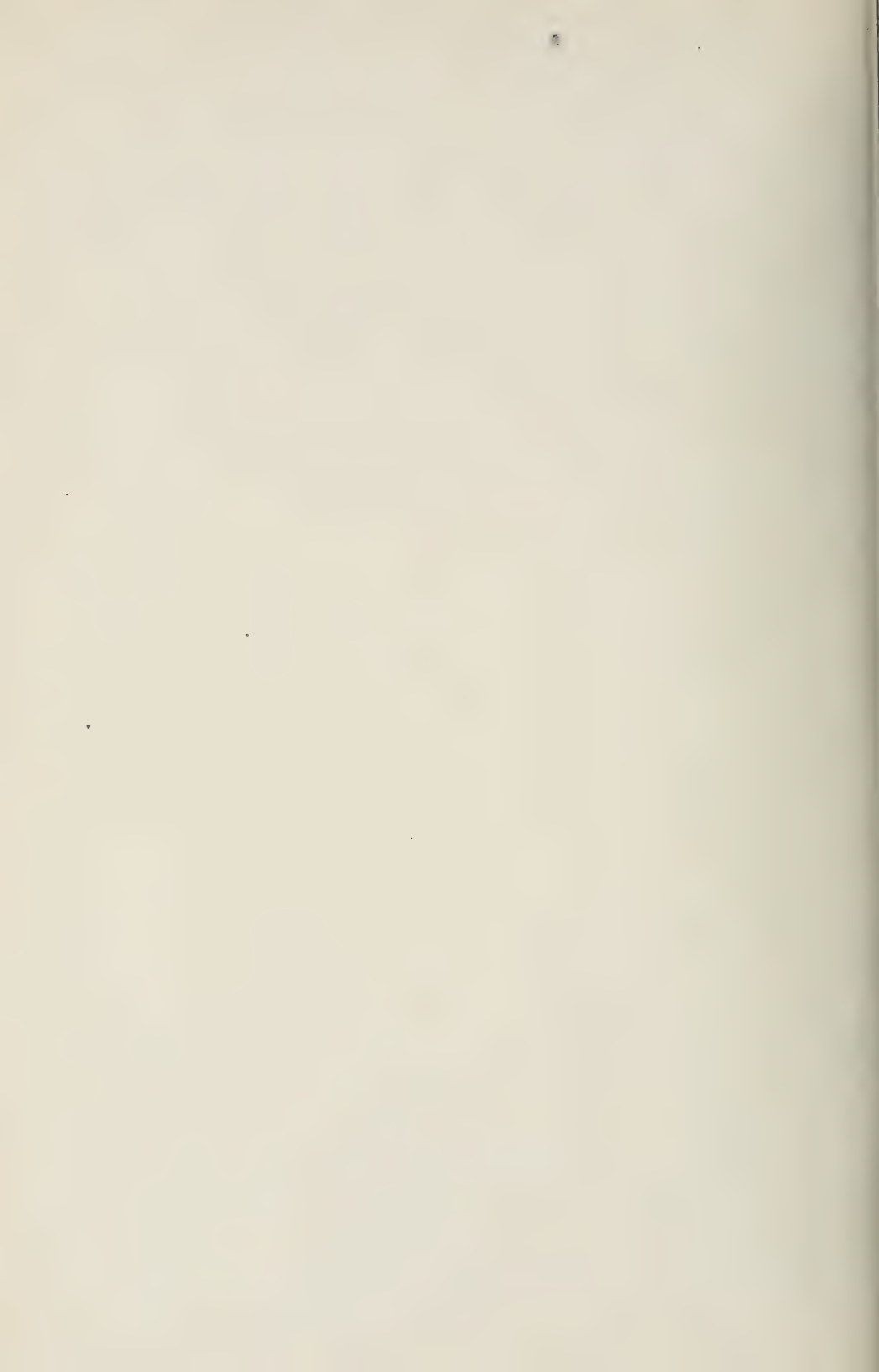
Mr. MOORE: Another question has come up: Has anybody here tried to hydrolize the lignone present . . . in the digester liquor?

The VICE-PRESIDENT: As no one answers, I think we can say that answer is No. If there is no further discussion of this paper, I would ask Mr. McKee if he wishes to make any remarks in closing.

Mr. McKEE: Excepting this, that I feel that we should do all we can to increase our war munitions, one of which is alcohol. If we take, for example, the requirements of the two smokeless gunpowder plants, one at Nitro, West Virginia, and the other at Nashville, Tennessee, their requirements for alcohol are enormous.

Mr. CHUTE: I was informed by an army officer as to the amount of alcohol he expected to use at the two smokeless powder plants which are being or have just recently been built; and it figured out that you would have to ferment 12,000 bushels of corn a day, under the ordinary American process, to furnish the alcohol that they expected to use in those 2 plants alone. That doesn't include any other present plants, or any other possible future plants. Twelve thousand bushels of corn a day would be required to make the alcohol for those 2 plants.

Mr. MOORE: Mr. McKee I think has not told the greatest use for alcohol which has come up: The United States government in making mustard gas is going to require 10,000 tons of ethyl alcohol a day. (Laughter.)



THE MANUFACTURER AND THE FUEL SITUATION

By WM. M. BOOTH

Read at the Gorham and Berlin Meeting, June 19, 1918

The activities of the first thirty years following the Revolutionary War were confined principally to agriculture and commerce. Manufactured articles were made in the home or were imported from Europe. Wood was abundant throughout the area east of the Mississippi River, and became the universal fuel.

The land was cleared that the soil might be utilized for crops, and the timber was burned. The introduction of iron smelting into New York and Pennsylvania created a demand for charcoal and potash was leached from wood ashes and exported.

As early as 1830 manufacturing was undertaken with great energy and all available water powers were employed to turn the wheels of flour, saw, cotton, woolen mills and tanneries. Wood was first used as fuel in steam power plants and upon the railroads. The charcoal supply of New York failed and largely because no coal was found, the iron furnaces were removed to Pennsylvania and Ohio.

Following the opening of our eastern coal, oil and gas fields, industries depending largely upon fuel have multiplied and have extended their operations westward and southward. Although Massachusetts, Rhode Island,* Connecticut and New York have within their borders no steam coal, the railroads and water ways have laid this commodity down at the doors of their plants at a very reasonable price, and with such regularity that we had forgotten that the supply might be curtailed, withheld, or might fail altogether.

The events of the past year have shown us how interests involving hundreds of millions of dollars of invested money are absolutely dependent upon a constant, adequate and reasonably priced fuel.

About twenty years ago economists in the employ of our government suggested that mining methods were wasteful, that boiler plants were carelessly run, and that what seemed to be an endless supply of natural raw materials must finally be exhausted. We doubt whether one householder or manufacturer in one hundred

* We do not consider the graphitic anthracite of Rhode Island "steam" coal.

listened with any degree of interest when he was admonished to conserve fuel.

In the meantime the price of anthracite has nearly doubled and the quality is often inferior. Excellent steam coal was delivered in Central New York in 1903 for \$3.00 per ton, and in New England at from \$4.00 to \$4.50 per ton. It was possible to obtain fuel in Chicago of fair grade for \$1.50 per ton. Imagine the surprise of the consumer when he was first charged \$6.00 and \$8.00 per ton for a coal of medium grade only, and was shortly afterward confronted with the prospect of a shut down because no coal could be delivered.

Fuel economists now have the attention of the public for the first time since coal became a cheap and efficient source of heat. Is it necessary to furnish inferior coal at an exorbitant price, and what would we do if our fuel supply were curtailed or withheld altogether? We are interested only in the fuel side of this question and will not enter into a discussion of prices.

Scientists who have made a study of the situation assure us that our anthracite is adequate for two generations, and that the steam coal supply is sufficient for our needs during several generations, but that the quality and consequent heating value of both will constantly decrease as more undesirable veins have to be worked. We are not then at the end of our resources from a fuel standpoint as some have believed. It is, however, necessary to conserve this against the day of exhaustion. It is self evident that the nation with the largest and best fuel supply within her borders is the best equipped for the struggle for supremacy in the world's markets.

The estimated areas of national coal fields include the following:

	Square Miles.
British Islands*.....	11,859
France.....	2,000
Belgium.....	500
Prussia.....	2,000
Austria.....	1,800
Russia.....	20,000-30,000
United States east of Rocky Mountains.....	214,000
United States west of Rocky Mountains.....	200,000-300,000

* Johnson's Encyclopedia, Article "Coal."

To get a connected idea of this subject let us sketch the fixation of energy:

Carbon and hydrogen are found generally distributed throughout nature. Only as they represent energy are they useful to man as fuels. Twelve per cent of limestone rock are carbon and 11.11 per cent of water are combustible material, but when found as limestone or water have no heating value. Sunlight only in a peculiar way can combine these elements to produce a body that will afford heat when burned. Carbon dioxide and water vapor unite in the plant to form starch.

This is the foundation of all life and activity with which we are acquainted. Starch is fermented to sugar or becomes cellulose. The latter is the basis of our fuel everywhere. The energy of the sun which shines by day only is held in a natural way and can be utilized at any time, night or day. We are able to move about, to light our houses, heat them or provide fire for boilers because energy of sunlight is stored temporarily by the union of carbon dioxide and water. This natural process has been active since plant life began and continues with few exceptions upon the land surface of the earth. Shaler says that organic matter is being laid down (in coal equivalent) in the Dismal Swamp of Virginia at the rate of 1 foot per fifteen hundred years. Authorities tell me that 4000 pounds of cellulose is a high figure for the annual yield per acre in our northern climate. This is equivalent to less than 1 ton of bituminous coal per acre or 1 foot in about eighteen hundred years. Fermentation with attendant loss of carburetted hydrogen and carbon dioxide probably increases the actual time for the production of even a high volatile coal four or five fold. We are surprised at the closeness of the figures offered. How, or under what conditions our present coal seams were formed is very imperfectly understood. We are able, as in the foregoing instances, to make a rough estimate of the time that would be required with our present climate. The results are not pleasant to contemplate.

Fuel is required in every civilized home to cook food, and in temperate and northern climates to serve as a protection against cold and dampness. We estimate the average annual consumption of a family in our latitude to be about fifteen cords of 14-inch seasoned hard wood, or 6 tons of anthracite. Due to scarcity of these basic fuels or poverty, substitutes are used in many localities. These include roots, reeds, peat, corn stalks, straw, dung, cobs, shucks, and corn.

Taking the population of New York State at 10,000,000, we have about 2,000,000 families. Using the above averages our wood consumption would amount to 30,000,000 cords or the annual yield of 7,500,000 acres,—3.75 acres for every family. The coal consumption would amount to 12,000,000 tons. These figures are derived from our own experience, and may differ somewhat from those compiled by others. Our aim is to illustrate the enormous fuel requirements for home use alone in a state more than 70 per cent of the population of which is found in cities and towns remote from wood lots or coal mines. The farmer is usually able to cut at least a few cords of wood; the city dweller is helpless. What we have said about New York State applies with greater force to the New England manufacturing states and equally to the northern sections of Pennsylvania, Ohio and Michigan.

During the past winter thousands of homes remained unheated for weeks at a time to the disadvantage and ill health of their occupants. The very urgent need for relief has been a daily topic of conversation.

Aside from the transportation difficulties, that can be remedied, we have a radical increase in the price of hard coal which is now forcing the poor man to turn to some cheaper fuel or to get along with much less comfort than has been his custom.

The solution of the fuel problem for the country home is the growth of wood,—coal should be saved for the city dwellers, who must use this or go cold.

We believe that the time has now arrived when chemists, engineers and inventors should apply themselves with great energy to the improvement of the home fuel situation. New and more economical apparatus should be designed and new sources of fuel investigated.

As in other matters we are extravagant in the use of fuel. The well-to-do live in over-heated houses detrimental from a health standpoint and expensive to maintain. One of our friends who was superintendent of a paper mill in China tells us that there was little or no fuel in the vicinity of the mill and that this was true of many of the northern provinces of that country. The wood was cleared centuries ago. Roots and grasses were used to cook food and the houses generally were without fires. Cold is overcome by increased clothing; undershirts and coats are multiplied to meet a decrease in temperature. It is perfectly possible to save several hundred thousand tons of coal here by adopting a similar plan. But a more necessary study is the

re-design of our house heating systems. The thermal efficiency of a new steam heater tested by ourselves was found to lie between 40 and 63 per cent. Three tons of coal out of the 6 consumed in the ordinary household are dissipated in chimney gases and in the ashes.

To the chemist who is always a conservationist, such losses seem criminal, and when found in millions of households the economic waste becomes very great. The most unfortunate feature of the whole situation is that coal once burned is lost to the race. We suggest intensive study of the heating systems of buildings, with the aim in view to return chimney gases to the air at approximately the temperature of that medium. The present chimney may be replaced by a simple gas exhaust tube extending from the cellar of the house. Proper insulation of walls and utilization of gaseous heat will result in a saving of 25 to 35 per cent of fuel. To accomplish such economies, the home owner will have to be furnished a simple apparatus very different from the modern stove or furnace.

The world's progress draws people more closely together. For social and economic reasons this tendency constantly accentuates itself. With a fuel shortage, community power and heat distribution become very attractive. Public service plants distributing from 20,000 to 50,000 H.P. electrically and by gas represent a positive fuel economy. We wish that the prices for both gas and electricity could be reduced 50 per cent and believe it would be possible to do this through the largely increased consumption of both that would result. If heat can be distributed to homes and offices economically from a central station such a system must become popular. It seems possible to overcome the excessive loss now prevalent in the distribution of steam due to the corrosion of pipes and fittings. Heat can thus certainly be carried long distances without serious loss and it is not necessary to transform fuel into electricity in order to do this. It may be possible that steam may be replaced by some less corrosive vapor.

Men unfamiliar with the conditions turn instinctively to water power as a source of heat. Let us see what 1000 available horse power can do for us as a unit. We assume that the loss is not more than 25 per cent between the water wheel and the home or factory which uses electricity. Such a loss would leave us 750 H.P. or approximately 560 kilowatts: 4,905,600 kilowatt hours, 16,742,812,800 B.T.U. or the equivalent of 620 tons of coal carrying 13,500 B.T.U. per pound. This coal at \$6.00 per ton would be worth \$3720.00. The investment necessary to carry out such a project would entail

an annual cost of more than \$20,000.00 upon a capitalization of at least \$100,000.00. East of the Mississippi River we consider the use of water power generally for heating purposes extravagant. The equivalent of our 6 tons of coal, home unit, would be about 10 water horse power continuously operating.

If the power of a stream were used to set free hydrogen gas which is capable of producing 62,000 B.T.U. per pound, let us see what could be done with this as a fuel. Dr. J. W. Richards writes in return to my inquiry that 250 pounds of hydrogen would be a fair estimate of the yield of 1 horse-power year. If we use 1000 H.P. as the unit as in the previous instance, we would have 250,000 pounds of hydrogen gas carrying 15,500,000,000 B.T.U. or the equivalent of but 570 tons of an average grade of bituminous coal; at \$6.00 per ton worth \$3420.00. This gas could be compressed and distributed at distant points by pipe lines or otherwise and would furnish an extremely hot fire with a heat efficiency of 80 per cent or better if properly utilized. Again the use of water power for the production of hydrogen gas as a fuel does not appear to be a good business proposition. Within our borders we have large areas of oil shale, brown coal and peat. The latter are almost useless in the eastern manufacturing district because we do not know how to handle them, and cannot compete with ordinary steam coal. In the event of a serious fuel shortage, elaborated fuels from these materials will necessarily become ordinary articles of commerce. Peat is found in New York State in large quantities and will become useful, when about 90 per cent of water which is present has been evaporated economically and when the remaining organic matter has been briquetted. In central stations lignite could be retorted and the gas used as fuel.

Up to the present time, as far as we know, nature has been allowed to take her own way in the production of cellulose. From a fuel standpoint few attempts, if any, have been made to increase the fixation of carbon dioxide and water over a given area. We feel that it is possible for the householder at least to replenish his fuel supply by a crop of a cellulose nature. It may be by the use of a starch material or the ultimate use of alcohol derived from a starch-bearing plant. Just how much heat can be stored upon an acre of land throughout the northern parts of the United States is an interesting problem to us and some members of the Institute may have already solved this to their own satisfaction. We have already stated in this communication that the average cellulose growth upon an acre is not

more than 4000 pounds annually. It is possible to raise 500 bushels of potatoes upon an acre of land or 30,000 pounds, one-fifth of which is starch. When dried or fermented to alcohol, this is available as a fuel. It occurs to us that a plant may be found that would produce a much larger yield of starch and perhaps of cellulose as well. Even in this climate, the actual waste material taken from an average acre of an Illinois corn field amounts to several tons and if this were retorted, we believe that the gas would carry enough heat to make the process pay. In the case of a fuel shortage, it is to be remembered that the straw of Kansas and the stalks of Illinois and Iowa are usually burned,—in some instances are turned under the sod to rot. Another thought that occurs to us in connection with this matter is the growth of an oil crop, the expression of the oil, burning the fiber and returning the ash to the soil. We cannot see how the land would be depreciated by such a process as oil is practically ash free, and very high in heating value. In our neighborhood, the willow industry is carried on to a considerable extent and a growth of 6 or 7 feet in one season appeals to us as a very rapid method of obtaining a cellulose yield which must amount to several thousand pounds per acre annually.

The economies that have been suggested for the home, apply to offices, public buildings and manufacturing plants. The fuel problem for schools is very grave and demands special attention. With anthracite at from \$4.00 to \$6.00 per ton, it has been our experience that school buildings are indifferently heated. Confronted by a fuel shortage radical changes must be made in equipment. Soft coal and coke will have to be substituted for anthracite in many localities.

We started this paper with the intention of discussing power plant economies but so much has been written about this subject and so little in connection with one equally important, that we have chosen the latter. It looks to us as though coal will have to be saved especially for the manufacturer. When we consider the importance of this branch of industry from a national standpoint every aid should be offered to broaden and extend it. The basis of manufacturing is raw materials, and coal is the most important of them all.

Some hundreds of miles away we have coal.

We are told that economies can be made in mining. Experts are in charge of this problem and we expect a solution.

Transportation facilities are ordinarily excellent. When unusual

conditions due to war are overcome, deliveries will assume a normal condition.

Fuel can and will come to the manufacturer as before, but he will find the price constantly increasing, and the quality diminishing. One reason for this is the actual value of the commodity itself. Our eastern coals are surpassed in heating value and quality by none in the world. In comparison with other fuels coal is sold at a low price. With a rising price the manufacturer must practice every possible economy in its use. He should investigate powdered fuel, surface combustion, producer gas, stokers, draft regulators, and should install sufficient recording apparatus to determine the cost of a kilowatt or horse-power hour with accuracy at least once per week.

The boiler house should be placed in the hands of men familiar with the theory and practice of steam engineering. All condensed water should be trapped back to the boiler house, and every B.T.U. possible conserved. What we have said about house chimneys applies equally to those of power plants. The manufacturer should utilize water power wherever possible. At night this energy could be used for heating.

As we understand our fuel problems the following suggestions are offered.

The small farmer or gardener could grow some kind of a fuel crop.

The farmer who owns at least fifty acres of land should raise his own fuel. If he depends upon a wood lot, 4 acres should be set aside for this purpose. More than the annual growth of timber should not be cut.

Country villages could be supplied by the annual over plus growth on the surrounding farms. Dwellers in large towns and cities may adopt the community heating plan, can also burn anthracite, coke, wood, soft coal, and gas. The public service companies should lower their prices for gas and prepare for four times the business they have ever had to the present time. This is a form of fuel which appeals to everyone. It has excellent heating power, may be made inexpensively and distributed at a low cost. We do not need to elaborate upon this subject. City household heating by a furnace, with the dust and dirt of coal and ashes and low thermal efficiency, is expensive and seems unnecessary.

In this paper we have not attempted to go into the subject of the fixation of sunshine by mirrors, heat-traps, burning glasses, by tides, waves, or windmills. The patent office records show that ingenious

men have spent a great deal of time upon all of these subjects. While a good quality of bituminous coal is available at a reasonable price, these more expensive methods of energy fixation must rest. We have made no attempt to exhaust this subject, and have tried only, to show the possibilities of fuel production and fuel economy. Although anthracite and bituminous coal are cheap in price, they represent an enormous outlay of sun energy in time and intensity, and it will be impossible for manufacturers during many generations to find anything that will equal them in heating value, unless a radically new invention shall enable us to fix the rays of the sun directly. Scientists have computed the number of B.T.U. actually available upon an acre, when the sun shines, and if we could get even 10 per cent of these into some reservoir from which they could be taken for power purposes, one of the great problems of our scientific world would be solved.

BRITISH THERMAL UNITS FOR \$1.00.

Bituminous Coal 13,500

B.T.U. per pound, \$4.00 per ton 2,000 pounds in one ton 6,750,000

Anthracite \$8.00 per ton

13,500 B.T.U. per pound 2,000 pounds in one ton 3,375,000

Seasoned hardwood

4-foot lengths, 4000 pounds. \$8.00 per cord 2,700,000

Natural gas 1000 B.T.U. per cubic foot

30 cents per 1000 feet 3,333,000

City gas

600 B.T.U. per foot. \$1.00 per 1000 feet 600,000

Crude oil

19,000 B.T.U. per pound. \$4.00 per barrel 1,615,000

Electricity 8 cents K.W. hour 4,266

Electricity 1 cent K.W. hour 34,128

Alcohol 95 per cent volume

\$1.00 per gallon of 6.58 pounds 78,302

DISCUSSION

The VICE-PRESIDENT: Mr. Booth's paper is now open for discussion.

Mr. MOORE: Have any experiments ever been done in relation to the concentration of CO_2 upon the rate of growth of the vegetation? The atmosphere, if I remember aright, contains about .03 per cent of carbon dioxide. Now, evidently, before all this carbon stored up in the form of coal—assuming that all this coal which has been stored up in the earth was at one time in the form of gas, there must have been a great deal of higher concentration of carbon dioxide in the atmosphere, and perhaps the rate of growth would be tremendously increased. Now, it has occurred to me that if there is an increased rate of growth due to the concentration of CO_2 , it is possible that the flue gases from all these factories might be taken and used over vegetation to increase the rate of growth. I would like to know if anybody has any information as to the rate of growth in respect of the concentration of CO_2 in the atmosphere.

Dr. HÖLLANDER: I would like to tell Mr. Moore that an article was published on that subject some time ago; I am sorry that I do not know any more where it was, but it was from this point of view, that in considering the amount of fertilizer usually given our plant crops: Nitrogen Phosphorus and Potash, the minor plants nutrients are overlooked, and CO_2 is one of them. Experiments showed that the yield was actually increased by the higher concentration of CO_2 in the atmosphere surrounding the plants. The report was probably in *The Journal of Industrial Chemistry* several years ago as a report from an Agricultural Experiment Station.

Dr. LANGMUIR: It seems to me that the question of fuel economy, particularly in manufacturing plants, is going to take care of itself automatically; because of the enormous increase in the price of coal; and I think you can depend upon manufacturers interesting themselves in the burning of coal economically as they have never done before. I think, on the other hand, that there is entirely too much said about saving coal, and cutting out coal for this purpose and that purpose. I notice that Mr. Booth rather enthusiastically speaks of those jokes suggesting the doing away with coal altogether for heating houses; that is, keeping ourselves warm by a large quantity of under-

wear. The entire effort of the fuel department in Washington seems to be directed toward saving coal, rather than mining more.

We have now, stored in the ground in Pennsylvania, Illinois and the Western States, millions and millions of tons of coal, enough to last hundreds of years. What we want is more coal. You cannot save coal enough to give us all our additional requirements; and if we can increase our shipping enormously, as we are doing—if we can increase railroad transportation by building more cars, why can't we have more coal? Let us save what we can, of course; but let us have more coal. (Applause.)

The VICE-PRESIDENT: I think there is another matter, which seems to me one of the greatest crimes at this moment, when we need all our natural resources; and that is, not to be able to develop Niagara Falls to its full limit. The idea of running away the enormous amount of power—throwing it away! It is just as if we were burning a spouting oil well continuously day and night for the beauty of the scene, and destroying millions of dollars of property in order to get the scenery. I understand that the treaty with Canada expires this year, I think on the 30th of this month; and the question is coming up now of having it extended for another year on the same terms. How much better it would be if restrictions could be removed entirely from Niagara Falls, allowing this development to go ahead; and, if necessary, it would be possible to—as been suggested many times—shut off the use of the water one day in the week, on Sundays; so that the falls could be seen once a week in substantially the same condition that they are now. By our present policy we are throwing away what is the equivalent of millions of tons of coal which can never be replaced. This water that is running away day and night is being replaced by coal and the waste is something fearful to contemplate at this time.

Is there any further discussion of this paper?

The SECRETARY: I am wondering whether we should not go on record, as an institute of technical men, on some of these questions. We sit here and discuss them; and I think we ought to produce tangible results; and I think the American Institute of Chemical Engineers is sufficiently representative so that our voice and opinion ought to have some weight.

Now, there are two things that have been brought out; one is, that we should produce more coal; and I think that Mr. Booth has, perhaps, not overemphasized the situation. It may become very, very

serious; and it may be that the authorities at Washington do not realize the vital necessity of producing more fuel; and I think Washington has shown, in the past—at least in the past few years—that pressure is necessary, and that we must bring pressure to bear in order to accomplish certain results at Washington.

The greater utilization of Niagara Falls is another important question. I believe the Electro-Chemical Society has passed a good many resolutions and probably forwarded them to the proper authorities and brought influence to bear to have the fuel situation taken up in a scientific way. My suggestion would be that this matter be referred to some suitable committee, that would take up both of these questions, and see what can be done: first, to increase the fuel production, and impress upon the authorities at Washington the necessity of it; and in the second place, to consider what can be done to utilize Niagara Falls more than has been done.

In passing such a resolution, or referring it to a committee, it seems to me that this body could go on record in favor of increased coal production and in favor of increased utilization of Niagara Falls; and then leave it to a suitable committee to bring this opinion to bear upon whoever has it in their power to do these two things.

The VICE-PRESIDENT: I think Mr. Olsen's suggestion is an excellent one. I don't think we should limit the recommendation to water-power to Niagara Falls; I think that all over the country in the past ten years there has been a great deal, I think of obstruction from governmental or state regulations to the development of water-powers, and that it might be well studied by some war industries board, or some board in Washington, to make a thorough investigation of what, if anything, is holding up development of water-powers in the various sections of the country, and special emphasis being laid on the situation at Niagara Falls, which we all know is acute.

The SECRETARY: I should like, Mr. President, to present what I have to say in the form of a motion or a resolution. The motion is that this Society is in favor and urges the necessity of increased coal production and increased utilization of our national water powers.

The VICE-PRESIDENT: With special reference to Niagara Falls.

The SECRETARY: It may be, Mr. President, that we ought to appoint a committee to-night, and let them come in with the resolution next Friday morning for final adoption along these lines.

The VICE-PRESIDENT: Is that motion seconded?

Mr. WESSON: I second it.

Mr. W. P. MASON: Would it be possible to have that in the shape of two motions, one dealing with the coal, and the other dealing with the water-power; or, if not that way, would it be possible to leave the motion in a general form omitting the Niagara Falls element of it? I only suggest that because I consider Niagara Falls is a pretty good thing to look at, and I have in mind a good many people to whom it will continue to be an attraction for some time to come. Personally, I would like, if I could do it by my say-so—I should like to save those falls. I doubt that I shall have personal influence sufficient, however, to save them; so my hope is somewhat diminutive; nevertheless I shall certainly vote against damaging Niagara Falls to-night. I believe that we ought to have a little something to make this world attractive, outside of the eternal chase of the almighty dollar. I want you to understand, however, that I like to feel myself in the front rank, when the elusive dollar is being chased. (Laughter.)

Dr. BEBIE: Would it possibly be advisable to further extend our motion that it would include not only the utilization of the water as a source of power, but also the utilization of the water as a means of transportation; because of the situation to-day that by the development of our waterways as a means of transportation a great deal of our transportation difficulties could be removed. For instance, right now a delegation of St. Louis is in Washington, trying to work together with the government for the further development of waterways for the transportation of coal and other heavy freight. Since our railroads are now under the control of the government, former objections to their use of waterways are practically removed. A very desirable relief in the transportation situation could be expected if the water transportation could be better utilized.

The VICE-PRESIDENT: It seems to me that could be the subject of another resolution. It would be a question of transportation linked up with the railways as well as waterways; while what we are discussing now is the question of the production of fuel or its equivalent in power.

Mr. WEISS: At the recent meeting of the Electro-Chemical Society in regard to water-power I think it was brought out very clearly that a lot of water-power development is mere boom development, and that water-power in itself can be tremendously overrated. In other words, for a given investment, unless the water-power can be used for twenty-four hours, it often is not a paying commercial proposition; and there are a number of instances of water-powers

which are not a commercial proposition. The thing is going to boil down for any particular instance to the question: Is it going to be cheaper to develop water-power, when you consider the uses that can be made of it, than to put in steam plants?

Another thing: what is the proportion of the actually available power of Niagara Falls to the total fuel requirements of the country? In other words, what per cent of it? I don't believe it is such a tremendous percentage of the total power consumption of this country; and I think we ought to look a little more on that part of the case before we put ourselves on record in any way.

Mr. SCHUELER: I was at a waterways meeting in Washington this week; and I think the government is going to recommend the building of a barge line from St. Louis to New Orleans; and along in that connection, I want to say that the question of fuel at the present time is a matter of transportation, and not of production. I know of any number of mines that are producing considerably more coal; but they can't get the cars to ship it in; and the matter of production at the present time is a matter of transportation and not a matter of mining.

Dr. WAGNER: Have we not a committee on resolutions?

The SECRETARY: No!

Mr. WEISS: I would move an amendment to that motion, to the extent that the committee at the time of presenting the resolution give us some facts regarding the proportion of power that the proposed change of Niagara would mean to the power requirements of the country.

The VICE-PRESIDENT: Is the amendment seconded?

Mr. HOLLANDER: Yes, I second it.

The VICE-PRESIDENT: Are you ready for the question on the amendment?

Mr. MOORE: It seems to me there is more or less of the absurd in this discussion. It is impossible to get the data of that by next Friday morning; and that would necessarily shelve the whole operation. I think later on a committee might report on it; but to get all those facts by next Friday morning as to the proportion of the power—Niagara Falls power—to the total consumption of the country is impossible—to get that data by next Friday morning; so that I think it is impractical, and will nullify the original motion.

Mr. LANGMUIR: Wouldn't it be possible for the Secretary to eliminate the Niagara Falls from that resolution, together with the

appointment of the committee, and let us settle the question to-night—to take a vote on the proposition—not bring up this question of Niagara Falls—just refer to water-power in a general way.

The SECRETARY: I think that any committee appointed by this body would naturally take into consideration the discussion to-night; and I believe that any committee that we would appoint, would certainly come in with a resolution such as they thought fit; and if, upon due consideration, the committee thought that Niagara Falls should be left out, they would probably leave it out. It seems to me, though, the very fact that Niagara Falls power is used, would seem to me to be answer enough; and, as I read the current literature to-day, there is a very, very insistent demand that Niagara Falls power be used; and, as I understand it, companies are moving to Norway or other places where they can get cheap hydro-electric power. It seems to me those are well-known facts; but I think the whole question would naturally be referred to the committee; and I believe in a body like this we can get considerable information between now and Friday; and it seems to me a committee could take it up and we could continue the discussion Friday morning.

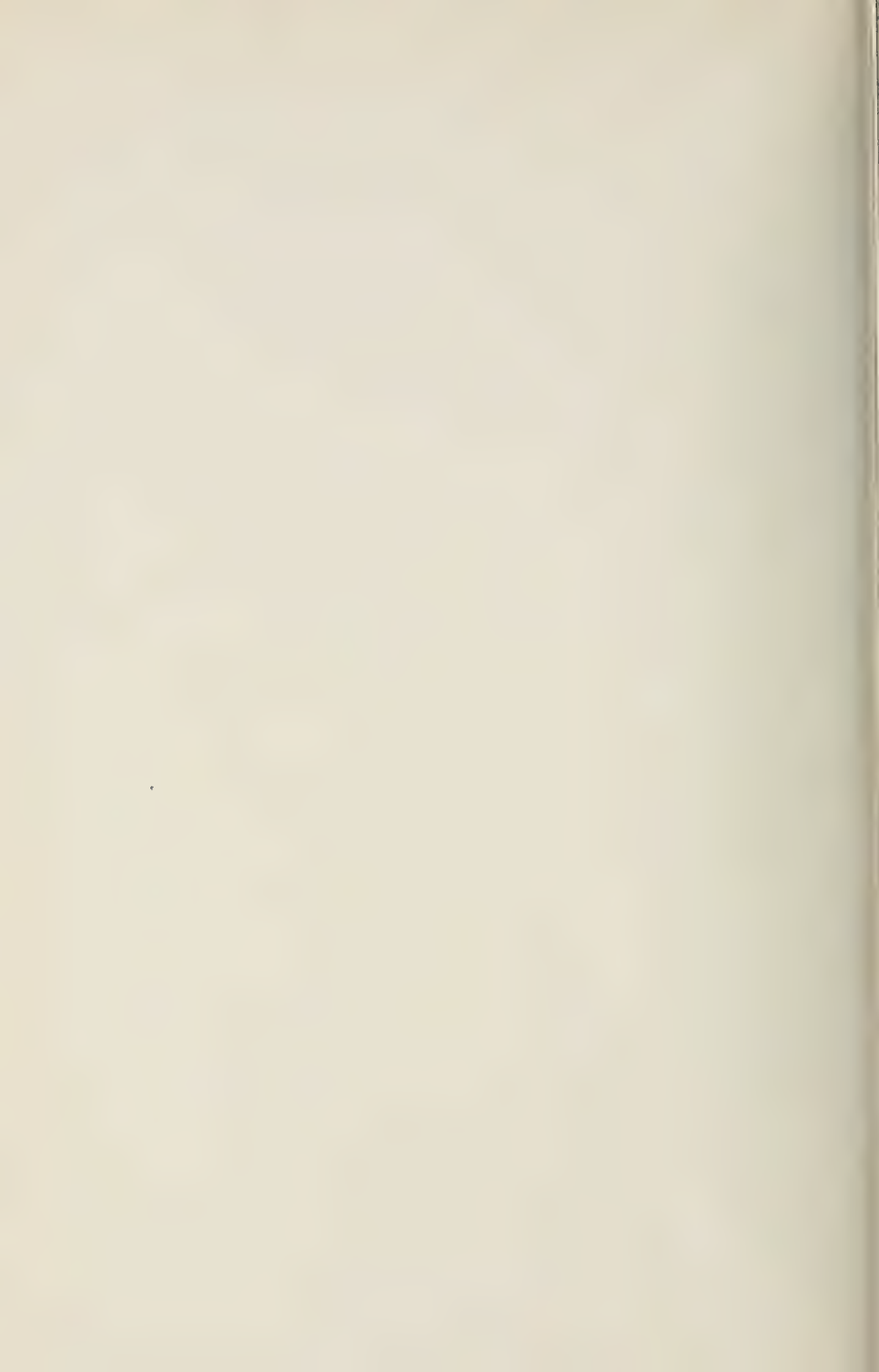
The VICE-PRESIDENT: Are you ready for the question on Mr. Weiss' amendment; that is, to amend by the words—the motion was that a committee be appointed to-night to draw resolutions and report to the meeting Friday morning; and that motion was made, and an amendment was offered by Mr. Weiss, that in presenting resolutions the committee should state the amount of power that would be available at Niagara Falls and what relation it bore to the whole power needs in the United States.

Mr. WEISS: I would withdraw that amendment and leave it to the judgment of the committee. I simply wanted to bring that one point forth, that we ought to know what proportion of the thing we are talking about.

The VICE-PRESIDENT: Do you accept his withdrawal?

Mr. HOLLANDER: Yes, sir.

The VICE-PRESIDENT: The amendment is withdrawn; and the question now is on Mr. Olsen's motion—are you ready for the question—appointment of a committee? All those in favor say Aye; contrary minded, No. It is a vote.



THE SEEDING METHOD OF GRAINING SUGAR

By H. E. ZITKOWSKI

Read at the Gorham and Berlin Meeting, June 19, 1918

There is a disposition in some quarters to deny to the sugar industry its claim as a member of the chemical industrial family. That the beet sugar industry, the direct descendant of scientific research and probably the oldest member of magnitude of the chemical industry family, should find it necessary to establish any claims in this direction is anomalous. Someone, sometime, as a labor of love, will bring out this as a matter of record.

Here I desire merely to state that nowhere else in industry has technical accounting been carried to a point as in the beet sugar industry. The beet sugar industry has taken laboratory manipulations or processes such as dialysis or diffusion, precipitation, filtration, evaporation and crystallization and adapted them to factory scale, handling millions of pounds of material daily, and with a refinement which taxes the ingenuity of the most expert manipulator to now duplicate on a laboratory scale.

It is even held that the beet sugar industry, which established itself in Europe during the Napoleonic wars, deserves to a very large degree the credit for the rapid development of the chemical industry of Germany. It was the beet sugar industry which furnished the technically trained and experienced men, capable of transferring laboratory reactions and processes to a factory scale and keep the commercial requirements in mind, when the modern chemical industry sprang into being.

Men go so far as to state that it was the beet sugar industry of Germany which made possible the terrible war that Germany is waging, not only because it was the foundation stone for the chemical industry but also because the cultivation of the beet brought with it scientific agriculture which doubled the agricultural yields, thereby making Germany largely self-sustaining and eliminating the threat

of being starved to submission by blockade. There is much that can be said in defense of such a viewpoint.

However, at this time here it is desired to discuss briefly the large scale practical application of the well known "seeding" method of inducing crystallization.

The oldest, and for many years the only method, of producing sugar crystals was to concentrate the properly purified sugar bearing syrups to the required density or supersaturation and set them away. In the course of days or weeks or even months, as the solution cooled, sugar would crystallize out. Even after the introduction of the vacuum pan method of "boiling" sugar, for many years, this was the only method and was known as "boiling blanks." Sometime during the fifties of the last century the art or rather the "trick of the trade" of "graining" sugar while yet in the vacuum pan was acquired though this was not generally adopted till twenty years later, and even up to this day frequently, for reasons which need not be discussed here, blanks are boiled. The general procedure at present is as follows:

A quantity of the properly prepared sugar bearing syrup with a water content of from 30 to 40 per cent is introduced into a vacuum evaporator or "pan" and is concentrated till saturated. At this point the boiling mass will be at a temperature of from 70° to 80° C., and under a vacuum of from 20 to 25 inches.

Now under certain conditions aqueous sugar solutions have the property of forming supersaturated solutions and in the presence of the non-sugars or impurities such as occur even in purified juices this tendency is greatly increased so that in factory practice it is always necessary to carry the concentration to some degree of supersaturation before crystallization occurs. Now it is not to be inferred that in all cases simple supersaturation will bring about crystallization, for, if the content of non-sugars or impurities in the solution is great enough, crystallization will not occur even though evaporation be carried to the point of dryness.

Under the normal conditions of sugar manufacture, however, that degree of supersaturation is finally reached at which crystal formation begins. Sometimes a sudden shock applied to the boiling, supersaturated mass is resorted to in order to induce crystallization, such as a sudden raising of the vacuum bringing with it violent ebullition, or the introduction of a hot syrup of a lower density which has the same effect, or the injection of steam or air into the mass. No matter how produced, at the moment of their formation the crystals

are infinitely small and some time is required to attain a visible size, though this may be only a few moments. Eventually the crystals formed do become visible and then the critical moment of the "boiling" of the "pan" arrives.

It becomes the attendant's business to allow the formation of crystals to proceed till, in his judgment, the proper number of nuclei for the apparatus in question have formed, then to arrest the formation of further crystals by lowering the supersaturation coefficient, which is done by lowering the vacuum, raising the temperature and diluting with syrup of a lower density. From then on it becomes his business to so regulate the temperature, the rate of evaporation and the introduction of syrup that the minute crystals will grow and, when the pan is full, be of the size to supply the market's demand.

Now not much time for deliberation is available when it is realized that often a pan holding 200,000 pounds of mass and yielding 80,000 pounds of granulated sugar is boiled complete in less than two hours. If the operator's judgment at the time of "graining" is at fault, and he allows the formation of too many crystals, the final product will be too small, may cause great difficulties in separation from the mother liquor and decrease the yield; if the number of crystals formed is too small the resulting end product will be too large, the time for crystallization will be longer and again the yield will be reduced. In both instances the cost of production is increased.

But even at best the crystal formation at the time of graining is not instantaneous, and by the time that some have reached a visible size others are at the point of formation, therefore infinitely small, with the result that the final end product is not uniform in size. This is objectionable, not only on economical grounds as the difficulty of separating the sugar crystals from the adhering mother liquor is greatly increased by uneven grains, but, also a fastidious consuming public demands not only a pure, white, sparkling crystal of a certain size (varying somewhat in different parts of the country), but the crystals must also be fairly uniform in size.

The above points out briefly some of the problems in connection with producing the "granulated" crystals usually found on our markets. Not all of the sugar produced is, however, so directly obtained as granulated. Much of the final output is first obtained as a "raw" or impure sugar, which is melted, reprocessed and recrystallized. The liquors from which these raws are obtained are of a lower purity and therefore present greater difficulty to crystal formation

or "graining." The impurities present, however, must not be above a certain ratio to the sugar present or crystallization in the pan will be entirely prevented and the mass will be blank or if crystals form they will remain so small as to be separated from the surrounding mother liquor only with great difficulty, if at all.

Eventually a final liquor, molasses, remains, which, in beet sugar manufacture, may contain 50 per cent of sucrose but also sufficient of impurities to prevent further crystallization. Any procedure, therefore, which increases the quantity of sugar recoverable by direct crystallization, or which increases the yield with each crystallization, or reduces the time element, or even merely simplifies the procedure may be very valuable. The saving may amount to only one hundredth of a cent per pound of sugar, and yet on the quantity of sugar produced, run into astonishing totals.

A very valuable recent development in the art of boiling sugar is the "seeding" of the saturated mass in the vacuum pan with sugar dust, to serve as nuclei for the sugar crystals, instead of the method above described of bringing about spontaneous crystal formation or "graining" by high supersaturation. Considering the simplicity of the use of sugar dust for this purpose and that it can be used without any expense or alteration of any kind in the equipment, this method is likely to prove to be one of the most valuable developments introduced into the industry in recent years.

While the method of "seeding" herein considered is a recent development, yet the principal underlying it is not at all new.

In U. S. Patent No. 489879 dated January 10, 1893, covering a Process of Obtaining Sugar, are found the following:

"It has, however, long been known that if such impure solutions are brought in contact with a sufficiently large number of crystals, a very effective crystallization can be brought about in the vacuum pan; and this knowledge has been made practical use of in sugar factories by the addition of raw sugar crystals to juices which could otherwise only be boiled with great difficulty. Similarly it is sometimes customary in sugar refineries, when very small crystals are desired, to bring the liquor to the crystallization point, and then by the introduction of a quantity of finely pulverized sugar to start energetic crystallization, thus insuring the formation of small crystals by shortening the time of boiling and consequently that given to the crystals in which to grow."

Similar references to "seeding" sugar can be found at even

earlier dates and yet it appears very doubtful that this method was ever successfully used in producing marketable sugar until less than two years ago.

To Mr. John C. Bourne, now somewhere with the Canadian forces, belongs the credit of having called attention to this subject, which led to the present development. Mr. Bourne was not familiar with the literature of the subject and was not aware that the idea had ever been suggested, to him it was entirely new.

The method as at present used very successfully, is as follows:

The sugar bearing syrup properly prepared is introduced into the vacuum pans and under the usual conditions of vacuum and temperature is concentrated till the point of saturation has been passed, that is, till the solution is slightly supersaturated or in the language of the industry, till it reaches a light "string proof." At this point a quantity of sugar dust, or powdered sugar varying from half a quart to two quarts for each 1000 cubic feet of vacuum pan capacity is introduced by aspiration, through suitable connection, beneath the surface of the boiling mass, care being taken to prevent the inrush of any considerable quantity of air as otherwise a portion of the sugar dust introduced is likely to rush up with the air and on into the condenser. This operation requires not more than half a minute. One or two minutes are required for the sugar particles introduced to mix through the boiling mass. For several minutes after the introduction or "seeding" the usual "proof" will appear blank or at best simply show a cloud, the sugar particles introduced being too small to be visible to the naked eye.

The solution, however, is supersaturated and is boiling vigorously and the crystals or fragments of crystals introduced immediately begin to grow and soon show on the "proof." Evaporation is continued till about that density is reached usually obtained by the older methods of "graining." From here on the procedure is as usual except that experience has shown that less difficulty will be experienced to keep out false grain or "smear" in a "seeded" pan than one "grained" by the older method.

The essential difference between the two methods is that in the one case the crystallizing nuclei are introduced ready made, in the other are formed spontaneously by highly supersaturating the liquor which carries with it certain objectionable features as previously pointed out.

The quantity of sugar dust to be used per unit volume of pan

capacity is dependent on the size of the dust particles and on the size of crystals required in the finished product.

In the writer's experience the "seed" used was such sugar dust as accumulates in the usual dust collectors of the sugar drying equipment. In size the dust particles ranged from an impalpably fine powder to particles just passing through a standard Tyler sieve of 100-mesh. Particles larger than this were screened out. In some instances powdered sugar as found on the market was used with success.

As a great difference in size or volume exists between particles or crystals just passing through a 100-mesh sieve and particles impalpably fine, it was considered that perhaps superior results would be obtained if the dust or "seed" used was more uniform in size. With this thought in mind trials were made with dust from which both the coarser and finer materials had been removed; improved results were not obtained if only the seed did not contain too many particles larger than 80-mesh.

Now while at the time of seeding a vast difference in size and weight exists between a powder particle and a particle of 100-mesh, when these nuclei have reached the market size little difference exists. In all probability the rate at which the crystallizing sugar deposits on the nuclei is in direct proportion to their surface areas. The surface area of an impalpably fine particle in proportion to its volume is so immensely greater than that of a particle of 100-mesh that as the two particles grow, the smaller growing at a relatively faster rate than the larger, the difference in size will become negligible.

Then, also, possibly the tendency of crystal splinters to regenerate the original shape of the crystals from which they have been produced may play a role, as the finer particles especially are largely crystal splinters.

This describes briefly the new method of "graining" sugars in the vacuum pans as practiced for the first time during the past campaign in a dozen or more beet sugar factories of the Western States. It deserves further study before all the factors are determined. However, the results obtained during the past campaign, in the factories coming under the Writer's observation, especially on the lower products, were uniformly superior to the normal results.

ROCKY FORD, COLORADO.

May 1, 1918.

DISCUSSION

The VICE-PRESIDENT: This paper of Mr. Zitkowski's is open for discussion.

Mr. LANGMUIR: I might give an instance of some of my own work a number of years ago as to the difference between large or small crystals and the powdered crystal. I noticed in this paper that the author recommends the use of powdered sugar or crushed crystals. I was asked some years ago—to prepare barium platinocyanide for X-ray screens. It was not easy to make the platinocyanide solution; but I finally succeeded and got a hot saturated solution and cooled it and obtained some handsome, beautiful crystals of barium platinocyanide, and submitted those to the screen manufacturer, who pronounced them a failure. He said he must have smaller crystals; so by stirring the hot saturated solution surrounded by ice-water I got crystals a great deal smaller. He said those were somewhat more satisfactory, but wanted them small enough to pass through a silk bolting-cloth; so I pulverized the crystals and sifted through bolting-cloth and submitted the powder to the manufacturer; and he said powdered crystals were absolutely useless. I learned afterwards that those small crystals were made by taking a saturated solution of barium platinocyanide and allowing it to crystallize in a rotating ball-mill. The crystals as they were formed are crushed by the balls and in that way they were able to cool the solution down without getting anything but the finer crystals.

Mr. SCHUELER: I might add a word on that crystallization. To get a real fine crystal, we make iron sulphite as a by-product of a pickling process in a steel plant; and some of the dealers who use our product want a real fine crystal; and we simply take the hot solution and have the equivalent of an ordinary chain-and-bucket pump; we raise that solution in the air, spray it against a board with the result that it takes about ten hours to crystallize a tank of solution, against a week for allowing it to cool in the ordinary way; and the crystals come out just like snow. It is a really fine—well, you can hardly tell it is a crystal, except by the microscope.

The VICE-PRESIDENT: Any further discussion of this paper?

WAR PYROTECHNICS

By G. A. RICHTER

Read at the Gorham and Berlin Meeting, June 19, 1918

A relatively short time previous to present hostilities we used the term pyrotechnics as a synonym for fireworks, and invariably associated the word with spectacular displays and holiday amusements. It is probably for this reason that the scientific world paid very little attention to this field of experimentation. As with the old-time glass industries, it was a common saying that a fireworks man must be brought up with the art, and could not be taught by modern methods. Recent developments have reversed this opinion, and as a result of investigation and experimental application, the field of pyrotechnics has broadened to a degree where it now constitutes one of the more important factors in the greatest conflict which the world has ever seen.

Civilization had progressed to a point where chemical methods for producing light, signals, means of communication, and camouflage effects were surpassed by other more convenient methods, afforded by the use of incandescent lamps, telephones, and brick walls. In the field of battle, where armies set up only temporary headquarters, the latest devices are wholly out of the question. Hence, we must resort to more primitive means of furnishing these necessary effects. Accepting such conditions, it becomes essential that we develop and perfect those means at our disposal in the best possible manner; therefore, the recent development along pyrotechnic research.

As indicated above, the interpretation of this term has broadened considerably. It now includes, not only fireworks in the old sense of the word, but also deals with the production of smoke, the development and design of incendiary mixtures and devices, the study of new explosives to be used for particular purposes, and the invention of relatively newer war weapons, such as the flame-thrower. All these

fields are being extensively investigated by the armies now contending in France.

For obvious reasons, it will be impossible to discuss in great detail the work carried out along these lines by the allied armies, but a general survey will be made of the entire proposition in order to place before you some of the problems which are involved in this research.

SMOKE PRODUCTION

Both the Allies and the Central Powers have made considerable use of smokes in warfare. Although smoke may be used either for signal purposes or spotting effects, the primary value of a smoke cloud lies in its obscuring power, and its effects are utilized both for offensive and defensive operations. The purpose to which the smoke is put determines largely the limiting characteristics and its chemical composition. For most purposes it is desirable to generate clouds which are non-irritant and non-toxic. On the other hand, in certain cases, an obnoxious and a toxic character may add to its effectiveness.

A cloud may be realized by detonation of an oxidizable material, such as phosphorus; it may be realized by an inter-reaction of chemicals, such as the ammonium-chloride cloud, or it may be generated by causing a material to evaporate and subsequently condense in the atmosphere, such as an oleum mist. There are other special methods for generating smokes, but in general, practically all types are formed by one of the above methods. The factors which determine the value of a smoke which is to be used by your own troops include:

1. Total obscuring power.
2. Compactness of material.
3. Ease of handling.
4. Stability and hanging properties.
5. General safety of material.
6. Control of operation.
7. Cost.

A high obscuring power is essential in all cases. Methods have been worked out by which a quantitative study of this obscuring power may be made. Observations indicate, and experiments prove the fact that white smoke is far superior to colored smoke so far as the obscuring power is concerned. The instantaneous effect realized is very important, but it is also necessary that a smoke generated retain

its effectiveness over a period of time. The relative rate of dissipation, due to the settling and agglomeration of particles, may be determined in a comparatively simple manner.

It is, of course, desirable that a compact smoke material be used. At the same time, the ingredients employed must allow convenient handling, and must also involve the use of substances or mixtures which are not likely to become sensitive or unsafe to transport. It is extremely important that the mechanical operation of the device be very simple in order that it may be managed by a non-technical man. The cost of material is somewhat secondary, although the sources of supply of chemicals recommended must be considered.

To date, phosphorus has figured largely in the smoke-producing materials employed by both armies. This substance is particularly well suited, since the oxygen and moisture necessary for the formation of droplets of phosphoric acid are taken directly from the atmosphere, thus rendering this method of smoke production very simple and efficient. Phosphorus has been employed in artillery shell, and grenades, and attempts have also been made to use it as a so-called burning smoke. As a whole, however, it may be stated that, to date, phosphorus has been used most effectively in detonating devices where a large surface resulting from the smaller particles is realized.

In practically every other type of smoke producer, all the ingredients of the resulting cloud must be incorporated in the original mixture. This means a much less efficient composition unless other factors enter to counterbalance the original concentration factor. An illustration of this type of smoke is the commonly known ammonium-chloride generator and the less commonly known sulphur-trioxide generator which has been employed by the Germans in France. This second device depends upon the principle of trickling oleum or chlor-sulphonic acid upon quick lime. The heat developed causes the formation of a sulphur-trioxide cloud.

Aside from the desirable factors enumerated above, the ideal physical characteristics which go to make an effective smoke cloud include: the realization of a most minute subdivision of particles, a cool and heavy smoke, and a cloud which does not depend entirely for its effectiveness upon the moisture in the air. It is always necessary to make certain compensations in order to decide upon the best all-around cloud for the purpose under consideration.

INCENDIARIES

The use of fire as a war weapon dates back to centuries before the Christian era. Authentic instances have been recorded in ancient history proving that so-called liquid fire was actually employed by contending armies during this period. In Pioneer days, the flaming arrow constituted one of the most formidable of weapons used by the American Indians. In our own time, the uses of incendiary weapons have been amplified, keeping step with other important war progress.

In place of the ordinary liquid oil, which was thrown over stone walls and embankments, we must now consider in our attacks the use of this flaming liquid by more effective methods, such as represented by the modern flaming gun. The portable flame-thrower has been used to good advantage in semi-offensive operations. Ease of control and distance of flame realized, determine the real effectiveness of such a portable device. The distance of flame actually obtained by this apparatus depends upon the aggregate of several factors, among which are: the pressure under which the oil is propelled, the size and design of nozzle, the type of valve, and last, but probably most of all, the character of the fuel employed. Under field conditions, operation is hazardous with any flaming gun so far in use and some reports indicate that the German commanders have selected the men for the work as a form of punishment for minor offenses. A larger unit, which may not be carried by one man, has been used. The prime object of this larger unit is to obtain greater length of flame, since the larger nozzle and greater pressure is used.

The flaming arrow has been used in several modified forms. Incendiary bullets are direct descendants of this primitive weapon. Phosphorus is often employed for the purpose, although it has usually proved to be poor incendiary material, when used alone. When used against wooden construction, it invariably coats the combustible material with an insulating layer of phosphoric acid, thus rendering it practically fire-proof. It is, however, effective when used against grain fields or highly inflammable objects, such as hydrogen balloons. The modern artillery incendiary shell is the second descendant of the flaming arrow; thermit and even oil mixtures are often employed in connection with this unit.

With the adoption of aeroplanes by both armies, each immediately resorted to this means of sending fire into the territory of their enemy.

Since the weight which a battle plane may carry is limited to a great degree, it becomes highly essential to provide some concentrated form of incendiary material to be employed in the aeroplane bomb. This proposition is continually under investigation by all armies, the idea being to realize the most effective incendiary in the smallest possible container. Selection of a suitable material for these purposes is sometimes very difficult. Generally the most intense heat, such as obtained from thermit, is necessary in order to pierce the roof or flooring upon which it lands. In addition to this first piercing effect, hot flame is desirable. The Germans have employed thermit in several forms, and have even incorporated chlorates with their hydro-carbon fuel.

The term, incendiary bomb, usually brings to the mind of a chemist the picture of an old-time experiment, using phosphorus in a carbon bi-sulphide solution. This suggestion has been offered to our government, and other governments, hundreds of times. It possesses one virtue; namely, that of being spontaneously inflammable, but this advantage is outweighed by its many disadvantages. Moreover, other far superior methods for producing a spontaneous ignition are known, and used when desirable.

FLARES AND SIGNALS

The subject of pyrotechnic signalling and of illumination of the battlefield at night is very important. Such illumination is used both as a defensive and an offensive measure. Surprise attacks are often rendered impossible, due to efficient illumination. On the other hand, by means of this artificial light, troops are able to distinguish barricades, and aviators are permitted a vision of the area to be bombarded at night.

The use of rockets and flares of various types seems to be the best means for the infantry in the trenches to communicate with aeroplanes, and they in turn with the artillery. This is particularly true during advances where such communications are essential for systematic progress. Red, green, and white lights have proved to be most satisfactory for ground flares since these are most distinctive and easily recognized. These flares are usually of cheap construction, generally from 1 to 4 inches in diameter, depending upon the use to which they are put. It is essential that they be airtight, easily broken open, and readily ignited. Such signals are placed in a shell-hole, or

in the trenches so that they are readily seen by aeroplanes, even in the day time. When used in this way they are not visible to the enemy except from above. Rapid communication is thus established between the infantry and artillery, and vice versa.

Rockets are employed both for signalling and illumination. With such a method of signalling, messages may be sent from trench to trench along an entire front without intermediate signalling from aeroplanes. This more rapid communication is advantageous under certain conditions prescribed by military tactics. Theoretically, there are a large variety of rockets which may be used for such purposes, but practically, a very few types are employed, since such a signalling process must not become too complicated to decipher rapidly.

Both colored lights and colored smokes have their respective advantages; colored lights may be of the parachute type which fall slowly and persist for a long time, or may be of the star type which fall rapidly, leaving a trail of colored light. Colored smokes are also used in both ways.

In addition to these more simple pyrotechnic devices mentioned above, there are many other special and more complicated pieces of apparatus; each of these has its own tactical use, and individual changes are made depending upon the nature of the problem to be solved. These special devices will not be considered in this paper. An attempt will be made, however, to outline briefly, chemical and physical factors involved in the production of a satisfactory illuminant, light signal, and colored smoke.

Aside from the fact that a flare must be safe to handle, of stable composition, and easy to make, its chief measure of efficiency depends largely upon the candle power obtained when burned.

Standard photometric data have been compiled for this comparison, and generally a flare is designated as having a given number of candle-power seconds per cubic inch of material. Given the size of a flare allowable, and the time of burning required, the only variable left is the average candle power during time of burning. First principles of chemistry have taught us that the exothermic character of a mixture is not the only criterion of candle power. The actinic rays from incandescent refractory particles passing up through the flare increases candle power tremendously. This is illustrated by the burning of a ribbon of magnesium. The ideal mixture must have a high reaction heat, the reactive products yielding these small particles,

mentioned above, which pass through the flame caused by the reaction.

The so-called aluminum flare is the one most commonly used by the armies in Europe. An old mixture of this type is represented by the following formula:

Barium nitrate.....	64 parts
Aluminium.....	20 parts
Sulphur.....	16 parts

Barium nitrate is a cheap source of oxygen. Sulphur is used as a retarder, and also to cause more uniform burning. It is often desirable to employ shellac instead of sulphur, this being particularly true when we contend with atmospheric moisture. The magnesium flare is not so commonly employed, due to the greater expense of material. In special illuminating devices where the initial cost of the mechanical parts is high, magnesium is generally used. On the other hand, mixtures of both aluminium and magnesium are often incorporated in devices of a semi-expensive nature. A deeper study of various factors such as comparison of cross section of burning area, mesh of mixture, type of binder, etc., is a subject large enough to warrant discussion in a separate paper.

The old-time use of strontium as a basic ingredient in a red flare is still in vogue. The old-time composition, however, has been subjected to great changes. In a similar manner, the green flare still employs barium, but it is used in a more efficient way than hitherto. The evolutions through which these mixtures have gone in the past three years, with the reasons attached thereto, is too large a subject to discuss at this time.

The problem of producing a colored signal smoke has probably bothered the fireworks man of years ago more than any one individual proposition. A white smoke is comparatively easy to produce. Obtaining black smoke is more difficult, but with the use of naphthalene and certain mixtures this has been accomplished. For the yellow smoke, arsenic sulphide is the old standby. Recently, red and yellow arsenic smokes have been incorporated very successfully in the usual pyrotechnic displays. The use of organic dye stuffs for this purpose has opened up an entirely new field, and decided progress has already been made. Such smokes are easily prepared, and cheap to manufacture.

Each new development along pyrotechnic lines leads to new uses at the front. It often happens that the urgent requests for special devices received from the battle line are anticipated by past work in the laboratories. This is, of course, desirable when possible.

An attempt has been made in this paper to touch lightly upon some of the more important aspects of the present field of war pyrotechnics. Considerable information has purposely been withheld, but will undoubtedly be submitted to the public in due time.

DISCUSSION

The VICE-PRESIDENT: Mr. Richter's paper is now open for discussion.

I would like to ask Mr. Richter regarding the SO_3 cloud he spoke about—whether you are quite sure that was produced in Germany from oleum trickling on quicklime.

Mr. RICHTER: Yes, sir, it is produced that way in Germany, also here; but we have other, more efficient methods at present.

The VICE-PRESIDENT: Couldn't it be produced in a more efficient manner from liquid SO_3 ?

Mr. RICHTER: In the form of shells, yes.

Mr. BEBIE: If chlorsulphonic acid is used, I don't see the necessity of using lime in connection with it. Couldn't simply water be used?

Mr. RICHTER: The additional heat is very advantageous, due to the speed of reaction. Of course, chlorsulphonic acid is also used; but it is not as efficient as oleum.

The VICE-PRESIDENT: I will declare the discussion closed on this paper.

SOME PHASES OF CHEMICAL MANUFACTURE IN JAPAN

By **ALCAN HIRSCH**

Read at the Gorham and Berlin Meeting, June 19, 1918

The purpose of this paper is to present to American chemists and manufacturers a brief view of chemical manufacture in Japan at the present time. I find that people in this country have many varied and often entirely incorrect ideas of present conditions in the Orient, particularly in regard to chemical manufacturing.

Of all the industries in Japan which have developed since the present world war, the chemical industry is assuredly the leader. The following figures are from a Japanese paper, the Hochi.

In 1914, 87 new companies were organized with a combined capital of \$300,000.00. In 1915, 63 new companies with a capital of \$1,500,000.00 were organized. In 1916, 220 companies with a capital of \$7,000,000.00 and in 1917, 282 companies with a capital of \$12,000,000.00 were organized. According to these figures from January, 1914, to January, 1918, 652 new chemical companies have been organized in Japan with a combined capital of about \$21,000,000.00. Compare this with the newly organized American dyestuff syndicate, the National Aniline and Chemical Company, whose stated capitalization is \$17,000,000.00. The purpose of this comparison is simply to emphasize the fact that we must first of all get as far as possible the Japanese viewpoint. It would be entirely erroneous to dismiss the Japanese chemical industry as being small and unimportant simply because the total capitalization since the war is of the same order of magnitude as one American company formed since the war. On the contrary, the Japanese chemical industry is very important, as I will hereafter attempt to show, but its importance must not be judged by the method which we Americans are too often tempted to use, namely, the monetary standard. The Japanese people are very cautious, and are apt to be rather skeptical regarding

new undertakings, and therefore prefer to start new industries on a small scale, and when successful to enlarge them. But these people are exceedingly industrious, and besides, their Government encourages and often subsidizes new industries which are important to the nation. Among the products, the manufacture of which the Japanese Government has encouraged and assisted, may be mentioned formaldehyde, glycerine, phenol, salicylic acid and dyestuffs.

Last September and October, there was held at Tokyo under Government auspices the first Industrial Chemical Exposition. It was a huge success, and ran for over two months. Among the exhibits were the following: Eighty firms and individuals exhibited industrial, or so-called heavy chemicals, which included barium salts, potassium bichromate, lead acetate, caustic soda, yellow and red phosphorus, bleaching powder, sulphur, iodine, salt, potash alum, aluminum sulphate, potassium chloride, hydrochloric acid mercury, sodium chlorate, potassium chlorate, caustic potash, yellow prussiate, nitric acid, potassium permanganate, hyposulphite of soda, glycerine, tannic acid, acetic acid, sulphuric acid, oleum, zinc chloride, etc. There were 32 exhibits of electrochemical products which included calcium carbide, calcium cyanamide, ammonium sulphate, graphite, ferromanganese, ferrotungsten, ferro molybdenum, ferrosilicon and electrolytic zinc. Two firms exhibited cylinders of oxygen, carbon dioxide, argon, helium, neon and nitrogen. There were several large exhibits of coal-tar distillation products which included refined benzol, toluol and naphthalene. Seventy-three firms exhibited dyestuffs and dyed goods. Eight firms exhibited safety matches, dynamite and other explosives. There were 45 firms who exhibited pharmaceutical preparations which included drugs, patent medicines, disinfectants, etc. Sixty-eight firms exhibited pigments, paints, lacquers and lacquer wares. One hundred and one firms exhibited porcelains, enamelled iron, clay products, glasses, cement, brick and ceramics. One hundred and fifty-one firms exhibited sugars, brewery products, paper and paper products, rubber and rubber products, mineral oils, oils, greases, waxes, soaps, perfumes and toilet articles. One hundred and sixty firms exhibited camphor, peppermint and turpentine oils, artificial fertilizers, leathers (real and imitation), photographic products, beverages, confectionery, celluloid, and chemicalized fibres. Miscellaneous—inks, shoe polishes, gelatin, isinglass, etc.

The above includes the most important chemical products. As

regards apparatus and machinery, 19 firms exhibited chemical, analytical and experimental apparatus, such as thermometers, balances, crucibles, chemical glassware, platinum ware, filter paper, microscopes, etc. Nineteen firms exhibited plant machinery, some of this machinery being imported, principally from the United States.

The above summary gives a fairly accurate idea of the various chemical products which are to-day being manufactured in Japan. Their variety and the manner in which practically every branch of industrial chemistry is covered, is certainly surprising.

I have given a presentation of the different chemical products which Japan is manufacturing at the present time, and now I wish to give some idea of the quantity or rather order of magnitude of their production, at least in some of the most important cases.

Japan is the greatest charcoal-burning nation in the world, and yet formerly imported as much as 10,000,000 pounds of acetate of lime annually from the United States. Modern kilns with complete recovery systems are now being installed. Formaldehyde is a chemical of national importance to Japan, as it is the only antiseptic used in the silk industry. The importations from America before the war averaged about 1,000,000 pounds of formalin annually. In 1911, the manufacture of this chemical in Japan was started, and during that year there were about 360,000 pounds produced. Thereafter, until the outbreak of the war, they manufactured about one-third of the formaldehyde which they consumed and imported about two-thirds. Since the war began, however, the Government has encouraged, assisted and protected the home industry and the firm of Toyo Takuhin Kaisha was established, having an annual capacity estimated at 1,500,000 pounds of formalin.

For quite a number of years, Japan has produced a certain quantity of heavy chemicals, but has also been a large importer of the same. The reason for this is that as different industries required more and more heavy chemicals, these chemicals could easily and quickly be imported, and thereafter the domestic plants could be built when the assured consumption of a certain tonnage was well established. Japan has produced during the last few years probably about 100,000 tons of sulphuric acid annually, and has also produced oleum. Certain plants have installed sulphuric acid recovery plants for the recovery and concentration of waste acids. Owing to the supply of a very fine quality of chemical porcelain, it is a growing industry

and a very successful one, particularly as regards quality of product. It is interesting to know that the cascade systems utilizing porcelain basins have been very successful. Acid resisting metallic basins, similar in composition to Duriron, are now being manufactured in Japan. Nitric acid is another of the heavy chemicals which has been made in quantity, and hydrochloric acid has been produced to the extent of something like 1,000 tons annually. Caustic soda has been produced in rather small quantities. The most reliable figures for the last few years estimate the annual domestic production at about 250,000 pounds, but at the present time a large modern plant for the electrolytic production of caustic soda is being installed. The manufacture of glass is a very successful industry, and considerable glass articles have been exported to India and Australia. The Japanese are very clever in manufacturing glass articles, and produce splendid chemical apparatus at a remarkably cheap price. They are making chemical glassware at the present time which compares favorably with the Jena glass. Glycerine is consumed to the extent of about 2,000 tons per year, and more than half of this was formerly imported. Since the outbreak of the war, a new company, the Nippon Glycerine Kojyo Kaisha, capitalized at \$1,500,000.00, was formed under the protection of the Japanese Government. It is stated that this plant has a capacity of about 1,000 tons of refined glycerine per annum. Paper is one of the important Japanese industries, and within the last few years there has been a remarkable development in this industry. It is difficult to obtain reliable figures as to the exact production of paper in Japan at the present time, but it is probably of the magnitude of 250,000 tons per year. Just before the outbreak of the war, Japan's annual consumption of wood pulp was about 120,000 tons per annum. About one-third of this quantity was imported from Sweden and Germany. Of this total, about one-half is ground pulp, the rest being sulphide pulp. The capacities of the home plants for producing sulphide pulp are being increased. One of the very important chemical industries in Japan is the manufacture of drugs and medicines. Formerly, practically all of the drugs consumed in Japan were imported from Germany. One of the leading concerns in this line is Sankyo & Company, of which Dr. Jokichi Takamine is president, who have modern plants and are manufacturing a variety of products among which may be mentioned phenol, salol, salicylic acid, aspirin, phenacetin, salvarsan, nio salvarsan, urotropin, pyramidon, etc.

At the outbreak of the war, Japan found itself totally dependent upon Germany for its dyestuffs, and the nation faced a dyestuff famine. The Government decided that the question of dyestuffs was a national question, and in December, 1915, authorized the organization of the Japan Dyestuff Manufacturing Company, Ltd., capitalized at \$4,000,000.00. The raw materials, such as naphthalene, benzol and toluol, come from gas works and from the Government coke oven plants of the Imperial Steel Company's works in the south of Japan. The Japan Dyestuff Manufacturing Company, Ltd., has modern plants for the production of electrolytic caustic soda, hydrochloric acid, nitric acid, oleum, sulphuric acid recovery, phenol, aniline, toluidine, tolidine, benzidine, naphthols, naphthylamine, naphthionic acid, etc.

Japan is very desirous of being independent as far as raw materials are concerned, and it has made great efforts toward this end. It has made great strides in this direction and has been successful in practically every instance with the exception of soda ash. For some reason or other, the manufacture of soda ash has not been very successful, at least so far as reports are concerned and Japan is dependent largely upon importations from England.

Electrochemistry is making great progress in Japan, and first on the list of products is calcium carbide. The exporting from Japan of calcium carbide has rapidly increased, and it is thought by many that it will be the leading item on Japan's export list. Before the war, most of the carbide was imported, only a small amount being produced in Japan. Since the war production has been greatly increased. About a year ago, there were about fifteen factories producing carbide, their combined production being about 28,000,000 pounds, valued at \$1,300,000.00. Since then, their productive capacity has increased and the total output is now estimated at more than 3000 tons. The total export of calcium carbide for 1917 up to the end of the month of November was slightly less than 5,000,000 pounds, valued at \$360,000.00. Practically no shipments of carbide were registered during previous years.

CHEMICAL STONEWARE

By A. MALINOVZSKY

Read at the Gorham meeting, June 21, 1918

The Manufacture of Chemical Stoneware is a separate and distinct branch of the Ceramic Industry. It is a branch that has received but scant attention in this Country as most of this class of ware was imported. Now that importations have been cut off, it is essential that we produce Chemical Stoneware equal, if not superior, to the imported article. This must be done if the Chemical Industry is to continue its growth and supply us with the many chemicals that have heretofore been imported or made in limited quantity only.

Chemical Stoneware is made in a great number of shapes and sizes, ranging from the simple evaporating dish to the most intricate arrangement of pipes and vessels and to containers of great size.

It requires skillful workmen for building up these various shapes and the utmost care in handling and burning them; but more than anything else, it requires the close and careful attention of a competent ceramic chemist to make selection of raw materials, supervise mixture and manufacture, from grinding and firing and to vary the processes to produce ware that will fulfill the requirements of the particular use to which it is to be put.

A good Chemical Stoneware should resist the action of *hot* and *cold* acids of all kinds (excepting hydrofluoric acid), be able to stand *sudden changes* in temperature, and be impervious to moisture.

It is usually the practice to mix different clays to produce a body similar in character to porcelain; therefore, stoneware clays are mostly used which contain enough flux to produce, at a high heat, a body with a very close structure.

If stoneware clays are not at hand, a low grade of fire clay can be substituted. The fire clay is burned to high heat, about 1400

to 1500 degrees Centigrade, where the iron and other impurities will act as the flux; or the fire clay can be mixed with an impure clay which has a very low fusing point. In this case the fire clay serves as the skeleton to preserve the shape of the articles from deformation, whereas the impure clay serves as the flux, which at high heat binds the particles of the fire clay into an impervious body. Other cheap fluxes can be added such as lime, or furnace slag, as the color is of no great importance. In this later case, there is a chance for the acid to attack the iron and also the clay body and disintegrate the whole body to a spongy-like mass.

Great care should be taken to produce a uniform body, as this is very essential in the manufacture of Chemical Stoneware. The best result is obtained by mixing and blunging the mixture or only the fusible part, which will be the fusible clay (preferable all the mix should be blunged) and then screened in order to remove all coarse particles. The surplus water is then removed with the filter press.

It is very necessary to screen the clay and remove all the coarse particles, particularly when taps and faucets are required which must be made tight fitting. The spigot and faucet are usually made from the same material as the body, some manufacturers preferring to grind the material finer for the spigot and faucet than for the body.

The joints in spigots or faucets have to be ground with water and sand or emery to make a close fit. If the coarse material was not removed, tight fitting of spigot or faucet would be impossible.

The body mix should be high in silica and still plastic enough to permit the shaping of large pipes and vessels, such as stills, condensers, acid container, and other vessels used in the Chemical Industry. And at the same time, it should possess an interval of from 200 to 300 degrees Centigrade between complete vitrification and deformation.

It is in this interesting field of Ceramics, more particularly refractories and Chemical Stoneware, in which the writer has been doing research work during the past several years of strife. The Company with which I am connected has undertaken the development and perfection of processes by which certain waste material and minerals not heretofore utilized, can be employed in making various ceramic products.

It is gratifying to be able to say that our efforts have been

successful, many tests of the ware, both in the laboratory and under actual working conditions, showing results comparable with the best imported products. Materials from many different States have been used in this connection and their suitability under the process proven.

Illustrating this feature, the following photograph (Fig. 1.) shows a stoneware body. The composition is highly vitrified and the ware has a structure similar to that of igneous rocks, excepting that it is more nearly homogeneous. It can be made of as close and fine grained a structure as porcelain. This stoneware consists of unfused and fused particles, held together by a vitreous bond. The different mineral particles are evenly distributed through the whole body and the unfused particles are enveloped by the fused particles, giving a strong interlocking structure which resists the action of moisture and of acids.

A test made by the author in our own laboratory yielded some interesting results.

Two crucibles and one vase, as you see in the picture, were placed in a gas fired dry oven and were gradually heated for 72 hours to 110° C. After they were allowed to cool in the oven to 90° C., they were placed in a large jar until cooled to room temperature and then were carefully weighed.

The small crucible weighed	192	grms.
The large " "	934	"
The vase " "	621	"

The crucibles and vase were immersed in water for 48 hours, then they were removed and the surface dried with blotting paper and carefully weighed again. The results obtained are as follows:

Large crucible has	0.856%	absorption
Small " "	0.521%	"
Vase " "	0.0325%	"

The same crucibles and vase were dried again and weighed as before.

The large crucible weighed	933.542	grms.
The small " "	192.000	"
The vase " "	620.372	"

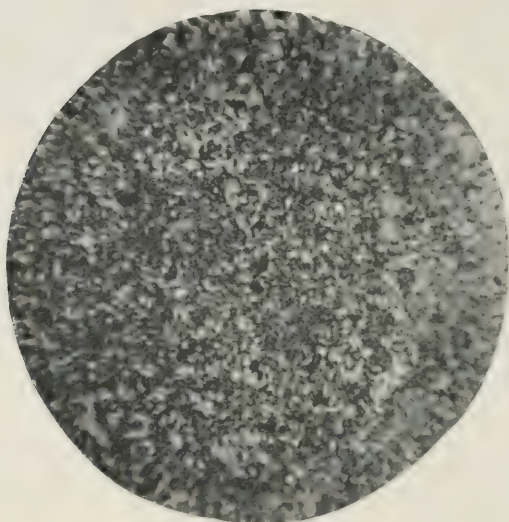


FIG. 1.

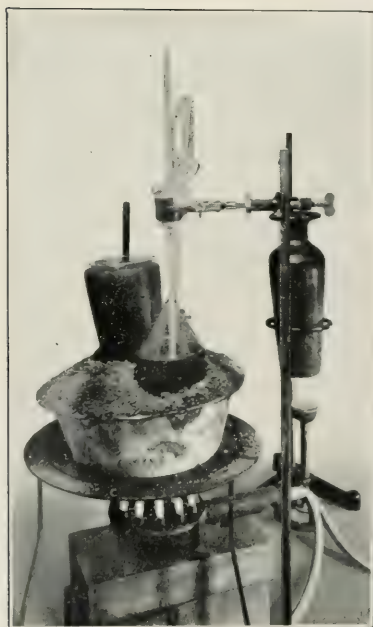


FIG. 2.

They were filled with commercial concentrated sulphuric acid 66 Bé. The two crucibles were then placed on a 14-inch iron pan filled with sand. Two inches of sand separated the test pieces from the pan.

Heat was applied and boiling continued for a period of twelve weeks. The temperature of the sand and acid was taken day and night. The record shows an average temperature of 128° C. We did not have at hand a gas regulator, and the temperature varied from 136° C. to 120° C.

The vase was subjected to the same test, excepting that the flame was applied directly to the vase and therefore it was more difficult to maintain a constant temperature. Especially was this true during the night when the gas pressure was stronger than during the day. Forty-two pounds of acid were used, since the test pieces had to be filled whenever the acid fell below half the capacity.

After the 12 weeks' boiling, the fire was turned out and the test pieces were allowed to cool. They were then washed some thirty times with brush and water, placed in a drying oven, heated to 140° C., cooled and washed again, and placed in the drying oven and heated to 140° C. They were then placed in a jar containing fused calcium chloride. After 24 hours they were removed and weighed with the following results:

The large crucible weighed	832.854	grms.	lost 0.0737%
The small	"	"	192.000 " nothing lost
The vase	"	"	619.763 " lost 0.981%

One of the crucibles was then broken and reduced to a fine powder which was passed through a 16-mesh sieve and then through a 20-mesh sieve. One hundred of the largest grains remaining on the 20-mesh sieves were selected and thoroughly washed with distilled water, then dried at 110° C., cooled in a desiccator and weighed. The 100 selected grains weighed 180 grms.

They were transferred to a platinum crucible and treated with the acid mixture of 10 parts of concentrated nitric acid, plus 25 parts of concentrated sulphuric acid, plus 65 parts of water. The platinum crucible with the contents of the 100 grains and acids was placed on wire gauze on which a 1/8-inch piece of asbestos 1 1/2-inch in diameter was placed, and gently heated to boiling and held at that temperature until the water and nitric acid was vaporized and

all sulphuric fumes were driven off. The whole operation took four hours. The crucible was then allowed to cool.

Water and nitric acid were again added and reheated to boiling and held for ten minutes. The contents of the crucible were transferred to filter paper and washed thoroughly until the wash showed no acid reaction with blue litmus paper. It required about 1500 cc. of water to wash the grains free from acid.

The grains were then dried in a drying oven to 110° C. for

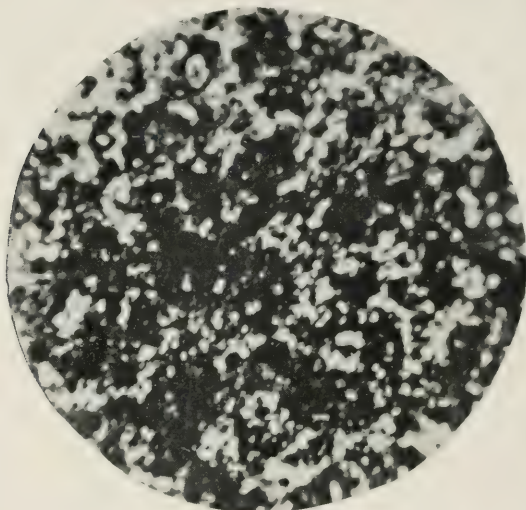


FIG. 3.

five hours, then transferred to a desiccator and weighed. The weight of grains was: 179 grms. lost 0.56%.

Then the grains were transferred in to the platinum crucible which was previously heated and weighed, heated for 20 minutes and then blasted for 10 minutes, then cooled in the desiccator. The loss shown was the same as before.

The slide shown is of a broken crucible and shows very clearly the structure of the body. You will notice in the photograph the crystals in a needle like form. This is known as the sillimanite. These crystals usually appear in the product made by the process formerly alluded to.

Microscopic examinations were made of several samples by Professor Rolin B. Salisbury, Geologist, University of Chicago, in

order to determine the structure of the material in the composition of this stoneware after it is burned. Also the writer has made microscopic examinations of many samples.

The examinations have shown that in all cases, in the vitrified composition, the burning has produced fusion enough among the materials used in making the ware, to develop a glass as in lavas. Notice on the slides that this glass serves as a binding material for the original grains which were not fused. These grains are bound together by the glass very much the same as are the crystals of some igneous rocks bound together by the glassy uncrystallized part of lava.

In physical composition therefore, this stoneware is very like a compact igneous rock which is but partly crystallized. The texture of the body is such as to indicate the possibility of a high polish so that spigots and stoppers could be ground to perfect joints, and the grain is so fine and even that clean cut lettering and carving is possible. This has already been proved very satisfactorily.

The descriptions of slides by Professor Salisbury are as follows:

"Under the microscope the material is seen to consist of grains of quartz, orthoclase, magnetite and altered ferromagnesian mineral in a glassy ground mass. This ground mass was developed in the burning and is the result of the fusion of parts of the substance of which the body is composed.

"Pore space about 11 per cent, but it should be noted that this is not the amount of space that will take up water, for the pores are in the glass and not accessible to water. The grains of quartz are angular (many) or rounded (fewer) apparently as they were before burning. They show little, if any sign of corrosion. The corners of the angular grains remain sharp, but there appears to be a very thin film of clear glass surrounding each.

"The feldspar grains, both orthoclase and plagioclase, are much altered on the outside, and grade into the ground mass without sharp demarkation. The smaller grains are altered throughout. Under the microscope the original grains are seen to be broken up into extremely fine fragments, which are bound together by isotropic material. The effect of the heat appears first to have fractured the grains and then to have fused the material along the cracks. The little particles into which the feldspars are broken

average about 0.002 mm. in diameter. There appears to be considerable kaolin, probably such as occurred in the original material from which the body was made.

"The ferromagnesian mineral is so much altered that its original character is not recognizable. But little of it is present. It is now altered to magnetite, surrounded by a brownish stain. It grades into the ground mass.

"The ground mass is of glass, filled with minute (amount .002 mm.) particles of quartz and feldspar.

"The union of the original particles seems to be as complete as in extrusive igneous rock which contains some glass."

It is interesting to consider the action which takes place between the alkaline earth and metals and oxides of silica, aluminum, and iron during the burning period.

When the fire is started the hot air passes through the kiln warming up the green particles and when the temperature of 110° C. is reached inside the kiln, the hygroscopic moisture is forced to leave the green ware, and at a higher temperature the chemically combined moisture is driven off and oxidation follows. When this is completed the oxides of bases and the oxides of silica and alumina combine in order to form various silicates. Naturally the bases (or silicates) which have the lowest fusing point will fuse first, reacting with the finest grains of silica to form silicates, and so in order follow the next ones which have a higher melting point, until all the required eutectic mixture is in a sufficiently glutinous state to bind all the non-fused particles with a glassy bond to a dense body.

At first the felspar substance in the body begins to soften and the fused feldspar is then attacking the clay substance while it is melting. However, the melting point of feldspar must not be misunderstood.

It does not melt to a liquid and flow, but only softens and adheres to the more refractory particles.

It is well known that the greater the proportion of undissolved material present in the mixture the longer will the ware resist deformation. This fact is proved by the hard translucent porcelain, where the potter builds up his frame work with kaolin to insure the articles against becoming deformed within the heat limit.

When the ware is sound and is vitrified to imperviousness, firing

has ceased, and cooling and annealing commences. Annealing is a process of gradually cooling which allows the silicates to settle and rearrange themselves in a condition of equilibrium. The annealing process is just as important in producing chemical ware as all of the processes in the manufacture of ceramics, to avoid molecular strain. And still it is the least understood by most manufacturers.

The importance of the annealing process is frequently to be seen in the case of glass tiles on sidewalks, which have broken or disintegrated into powder. The reason lies in the fact that the glass, in the molten state, was poured into the steel mold and pressed. In this way, the glass was chilled rapidly and the molecules on the surface rushed to adjust themselves. As a result, the glass becomes intensely solidified which prevents the molecules of the interior from rearranging and uniting. We can easily see that the glass is in a state of continual strain and is prevented from collapsing only by the intense rigidity of the exterior walls. As soon as the surface of the glass is scratched or broken, the whole tile breaks into pieces, and sometimes makes a violent noise. This is true with the stoneware also. If cooling is hurried too much, the ware will be brittle and invisible cracks will occur.

Cooling too slowly will cause too much of crystallization of the magma, therefore, the cooling can proceed very fast until the temperature has fallen to red heat, say 1000 or 800° C. when freezing temperature of the eutectic has been reached; from then on cooling has to proceed very slowly, especially when the body is high in silica.

A very good idea of the formation and behavior of the silicates in the glass or ceramic bodies can be illustrated as follows:

Assuming that this is a dancing hall, everything quiet, all persons present are seated. Some may be in a standing position eagerly waiting for action. The orchestra commences to play. As soon as the music starts, every one hurriedly looks for his partner and then the couples dance around the hall, one pair after the other. We never find that all the persons commence to take action at once but pair after pair until all are dancing, excepting the people on which the catalytic action of the music has not taken effect.

As soon as the orchestra stops playing, the couples return to their places quietly and rearrange themselves orderly for the next action. Had there been any disturbance in the orchestra or

among the dancing couples, the music naturally would have stopped at once and every pair would have parted in disorder, running unsettled in all directions. From this we learn that the orchestra had furnished the function as a catalyzer, to produce action in the persons present in the dancing hall.

This is also true with the heat. When burning the chemical stoneware, the heat is in reality not consumed, it only performs the action of the formation of the different silicates in order to produce vitrification in the ceramic bodies to make it impervious to moisture and acid.

So we can see that the function of the heat as a catalyzer is exactly the same as the music; every molecule of heat is given off as soon as it has accomplished the required result.

DISCUSSION

The VICE-PRESIDENT: The paper is now open for discussion.

Mr. KINGSBURY: Chemical stoneware is also affected by phosphoric acid at temperatures above that at which stoneware apparatus is not ordinarily employed. At the temperatures to which chemical stoneware is subjected under ordinary industrial conditions, the action of phosphoric acid is not sufficiently great to render its use inadmissible.

Mr. WHITAKER: I have followed this paper with interest, being interested in the ceramic field myself; and it seems to me that the author has emphasized one property—one important property—of chemical stoneware rather to the exclusion of other properties which are probably just as important. He has gone very closely into details regarding resistance to acids, and has described a test—in which a crucible, which he treated with dilute sulphuric and nitric acid was weighed after treatment and a loss in weight found of less than one-tenth of one per cent. This material was undoubtedly very close grained and burnt at a pretty high temperature, as he mentions the presence of sillimanite crystals in the body, which are characteristic of porcelain which is burnt at a comparatively high temperature.

The question is whether a body of such close texture and such high vitrification could be successfully used in the manufacture of large and complicated pieces. It is a simple matter to use a body of this kind for small ware, and small pieces for laboratory

work where indeed porcelain is commonly used. You can make small laboratory pieces of porcelain, but you can't enter the chemical stoneware field and make large pieces out of a porcelain body. It has been my experience that a stoneware body which under the treatment which Mr. Malinovzsky describes—shows as high a solubility as $1\frac{1}{2}$ per cent, is entirely satisfactory for commercial use.

There is another important point: the most important point, probably next to the question of resistance to acids, that is, the question of resistance to temperature changes—which the author merely refers to superficially. There is no doubt that vitrification can be overdone. If you get the vitrification as high as in porcelain and use this body in making large pieces, it will undoubtedly give way under temperature conditions. It has been my experience that a body in the shape of a small vessel can be heated directly over a Bunsen flame for hours at a time, as was done in this instance, without suffering any damage; but as soon as the body is made heavier, thicker and larger, you get entirely different stresses and the vessels go to pieces. That is the second important property and the third is the tensile strength of the burnt body, which is becoming more and more important under present conditions.

The chemical industry is using chemical stoneware nowadays in many different ways from what it was doing some years ago. If you take for instance, machinery which is now being made of chemical stoneware such as exhaust fans, pumps and also acid eggs, where the tensile strength of the body plays an important part, it would seem that this is a property which cannot be overlooked. I have some figures here to give you an idea of what the tensile strength of stoneware is. The average English stoneware was given by some English chemists last year or early this year in an English publication as 600 to 800 pounds to the square inch; and the best German was given as 842 pounds; the best American chemical stoneware body has as high an average as 1135 pounds, whereas some special stoneware, which borders on porcelain of close bond and high vitrification has as high an average as 1680, up to a maximum of over 2000 pounds to the square inch.

These three properties are, perhaps, the most important and while it is easy—I won't say easy, but comparatively simple to get a stoneware body which has any one of these properties, that is, a high vitrification, in which the other properties are absent or a body

which will stand changes of temperatures, without showing high tensile strength or vitrification, the difficulty is to combine these three properties so that the body will not only show resistance to acids, but will also stand temperature changes and have high tensile strength to permit it to be used under conditions where such properties are essential.

The VICE-PRESIDENT: Is anyone here manufacturing the silica lined iron tanks that used to be imported from Germany?

Dr. ZIMMERLI: The so-called silica lined iron equipment is made of cast iron or steel coated with glass enamel. It is impossible to coat a tank with pure silica because the melting point of silica is too high and glass of the proper properties with a melting point lower than that of the metal to be coated must be used.

Acid resisting enamel for glass lined ware is taking its place permanently in certain industries. All of the equipment on the market for acid resisting ware, like stone ware, enamel or glass lined ware, or separate metals and alloys, have their particular uses in the processes of manufacture. It does not seem as though one of them competes with the other.

The VICE-PRESIDENT: There must be some others who have had experience with stoneware. Dr. Bebie, have you anything to say?

Dr. BEBIE: No, I don't think I have anything to add to it, but I agree with Mr. Whitaker's statement that resistance to acid is only one of the features to make a good chemical stoneware. It is certainly very important that the stoneware should stand changes of temperature. Sometimes it happens that you want to use the same apparatus which you have used—at low temperature—for another process where we would use it at high temperatures.

Mr. KINGSBURY: We have been thinking seriously of taking up the manufacture of these kettles but we have not started yet. The probabilities are that when we are a little less busy we will go into that line.

The manufacture of these kettles requires a high degree of skilled labor. At the present time we are somewhat handicapped for lack of skilled men, some of them having been drafted and others leaving us for employment where they can secure higher wages.

It is likely that when conditions are again normal we will take up the manufacture of these kettles.

Dr. ZIMMERLI: What is the cement used for that brick?

The VICE-PRESIDENT: I don't know.

Dr. ZIMMERLI: Is there water-glass connected with it?

Mr. KINGSBURY: Yes. The kettle is made cylindrical with a practically hemispherical bottom and the tiles are ground on all edges. The cylindrical shell is usually made in two parts and after the tiles are laid in position the two parts are drawn together which forces the ground edges of the tiles together so as to get practically a stoneware to stoneware joint all over the cylindrical surface. The hemispherical bottom is also drawn up to the cylindrical part of the vessel and is closed in the same way.

The SECRETARY: There is cement used?

Mr. KINGSBURY: The cement is squeezed out through the joints as the tiles are drawn together and it is then pointed and cleaned all over the inner surface.

Mr. CHUTE: Let us remember that all these digesters that we have seen lately of enormous size, which are used in converting the wood into pulp by means of a solution of bisulphite of lime saturated with sulphurous acid—these digesters are all bricklined and cemented, as I understand it, with a mixture of glycerin and litharge; and the acid-resisting qualities of them must be considerable as they are submitted, as we saw, to 80 pounds steam pressure, and are continuously charged and discharged, cooled and reheated, more or less necessarily, but the cool solution coming in and the large amount of live steam blown in; so that we might consider the sulphite digester as a very large piece of acid-resisting stoneware.

The VICE-PRESIDENT: Is there any further discussion?

Dr. BEBIE: In connection with enamelled tanks, I will mention that we find that the enamelled tanks which are made here in one way do not compare favorably with enamel ironware which used to be imported from Europe, that is, in their resistance to the changes in temperature and consequently the resistance to the actions of acids. The European material was enamelled cast iron; whereas, our manufacture is mostly enamelled steel; and enamelled steel has more of a tendency for warping, when exposed to changes of temperature; sometimes very small portions of the enamel are chipped off; sometimes a tank has a fine pin hole; the result is that the acid eats through the steel and the kettles have to be thrown on the junk-pile after short use.

The VICE-PRESIDENT: Do German manufacturers ever guarantee those enamelled kettles?

Dr. BEBIE: No, there was no guarantee.

The VICE-PRESIDENT: Is there no enamelled cast-iron being made in this country?

Dr. BEBIE: Not as far as I know.

Dr. HOLLANDER: Yes, sir—enamelled cast-iron made right opposite to us in Burlington, New Jersey, by Stuart & Peterson.

Mr. MALINOVSKY: Mr. Whitaker stated that I have gone very closely into details regarding resistance to acids, and that I have emphasized only this one property rather than other properties which are probably just as important.

I agree with Mr. Whitaker's statement that the three factors to which he refers, that a chemical stoneware should possess resistance to acids, resistance to thermic changes and should have strength, and that all these three points are very important to have in stoneware.

If you read the fourth paragraph, page 106, you will kindly notice that I have stated in this paragraph myself, that a good Chemical Stoneware should resist the action of *hot* and *cold* acids of all kinds (excepting hydrofluoric acid), be able to withstand *sudden changes* in *temperature* and be impervious to moisture.

Mr. Whitaker stated that a Chemical Stoneware which shows a solubility of 1.5% under the same treatment is entirely satisfactory for commercial use.

It depends on the structure of the vessel and condition of the acid. My experience is that if the Stoneware body is once attacked so that it commences to dissolve 1.5% in the first half year, the dissolving action of the acid on the Stoneware body will go on more rapidly in the next half year.

If the Stoneware is once attacked, the dissolving action continuously produces minute cavities, which can cause very serious conditions, especially on the people conducting the plant.

We have information at hand that workmen were frightfully burned and some permanently blinded. I myself had many times received very unpleasant splashes.

Therefore I state in my paper that the success of the manufacture of Chemical Stoneware depends, first, on the material and its preparation, second, on design and careful workmanship and

third, on density including strength. Without the density the best designed Stoneware made from the best selected raw material, by the most skillful workmen is valueless, and dangerous to use in Chemical Industries.

It should give us a very good idea, if we take into consideration, for example, a modern nitric acid plant. Where the highly corrosive acid and fumes is continuously in contact with the Stoneware, and is to be pumped from the acid egg up to the top of the tower, I should say 36 feet high, the acid of sp. gr. 1.30, will give a pressure of about 25 pounds per sq. in. The Gay Lussac tower with a pumping height of 60 to 70 ft., using H_2SO_4 of a sp. gr. 1.60, will give 50 pounds pressure per sq. in.

This should demonstrate sufficiently that when the egg and piping must have the resistance to withstand this high pressure, the Stoneware must be made dense. If the body is absorbent or is attacked by the acid or alkalies the stoneware cannot resist the pressure after a certain time has lapsed, but will sweat through the Stoneware or the acid may be forced through the walls by the pressure.

The assumption that the strength of a chemical Stoneware is in proportion to its thickness, has proven many times unsound as I have seen Stoneware which has given way at its thickest part.

Faulty Stonewares are produced by many influences: by incorrect design, careless filling of the molds, the strains which are set up in drying and burning, carelessness of the primary and secondary preparation of the raw material used in making Stonewares. The process and care which should be exercised in manufacturing chemical Stoneware is responsible for the success and failure.

Failure is also produced in chemical Stoneware by applying salt glaze. I have seen chemical Stonewares which were salt glazed and the result was a failure. This also happened with me. Some of my Stoneware was burned together with other ware which was salt glazed, but not at that high heat were my Stoneware body mature.

The salt is too high in alkalies and it may be noticed that it is covered with a very fine network-like craze which can be seen very plainly with the help of a microscope. Through this network the acid finds its way and will penetrate behind the salt glaze and will cause the destructive work by dissolving part of the body especially that part which is not vitrified or burned hard enough.

In my experience I found that the best result is obtained if we want to apply a glaze to the stoneware to protect the surface by applying a feldspar glaze, especially an orthoclas feldspar glaze of the porcelain type. A glaze like this is always under control and is not attacked by alkalies or acids.

But the most satisfactory method is to vitrify the body as far as possible. A good vitrified body with glaze or without it can always be cleaned. A good sound chemical stoneware can be cleaned very easily.

Mr. Kingsbury mentioned that phosphoric acid also attacks chemical stoneware at a high temperature.

The action of phosphoric acid on chemical stoneware or on any ceramic well-burned body is hardly noticeable, if at all, at a low or a high temperature.

In ceramic raw material phosphoric acid is a very desirable constituent, as it produces vitrification, gives translucency to the body, and enamels, and also produces good color. In clays phosphates are usually found in amorphous or crystalline state.

THE EXPANSION OF THE COAL TAR CHEMICAL INDUSTRY OF THE UNITED STATES

By F. E. DODGE

Read at the Gorham and Berlin Meeting, June 21, 1918.

I have been so occupied with my work connected with the production of Toluol that I have had no time to prepare this talk which must, therefore, be very disjointed.

The expansion of the coke oven industry is, of course, the basis of the expansion of the Coal Tar and Coal Tar Chemical industries. It may, therefore, be of value to devote a little time to it.

The building of by-product coke ovens in the United States started with a plant of twelve small Semet-Solvay ovens at Syracuse in 1893. At the end of 1914, there were 6438 ovens in operation, carbonizing 24,000,000 tons of coal, or approximately 33 per cent of the coal coked. The outbreak of the European War which made great demands for iron, steel and chemical products produced the necessary conditions to make attractive the building of by-product coke ovens. About 3500 ovens were built in 1915, 1916 and 1917, and some 2000 more are building at the present time. There is every reason to expect that the building of beehive ovens with the waste of the by-products has at last stopped. It is estimated that the total coal coked in these by-product ovens during the current year will be 40,000,000 tons, or slightly more than one-half of the total coal coked.

While the needs of the Allies for steel was the initial cause of this rapid growth of the by-product coke industry, their need for explosives was the cause of the rapid increase in Benzol recovery which is now conducted at all of these oven plants.

Tar and ammonia were, of course, always recovered, the first because it was a nuisance, and the second because of its ready sale. There were produced from by-product coke ovens in 1914, tar, 110,000,000 gallons; ammonia, expressed as the equivalent in ammonia sulfate, 140,000 tons. It is estimated that there will be

produced this year 300,000,000 gallons of tar and 330,000 tons of ammonia, expressed as the equivalent in sulfate of ammonia. Owing to the scarcity of fuel several of the large steel companies are burning coal tar.

When the war began, there were only five plants producing refined benzols, two refining naphthalene, and one made all of the phenol. Synthetic phenol had been produced by one plant, but had been discontinued, because of the unprofitable price of phenol. No light oil was recovered from by-product coke ovens in 1914, except from the 1700 small ovens operated by the Semet-Solvay Company.

Now about forty by-product coke oven plants produce the refined benzols, besides several plants refining miscellaneous oils.

The total production of the above refined products in 1914 was:

Benzol	3,000,000 gals.
Toluol	750,000 "
Phenol	120,000 lbs.
Naphthalene	3,000,000 "

and the estimated quantities for 1918 are:

Benzol	40,000,000 gals.
Toluol	14 to 16,000,000 "
Phenol	75 to 80,000,000 lbs.
Naphthalene	45,000,000 "

In 1914 only one-quarter of this benzol and toluol was produced from by-product coking of coal. The balance came from water gas tars and oils, holder oils, gas drips and pintsch hydrocarbon.

All of the Phenol was the natural variety extracted from coal tar oils and refined in one factory.

In the current year from 10,000,000 to 13,000,000 gallons of Toluol will be produced by by-product coke ovens.

Of the current phenol less than two per cent is extracted from tar oils, the balance being made synthetically from benzol in the numerous plants erected since the war began to furnish phenol for picric acid.

The prices of these materials were prior to the war:

Benzol	30- 35c. per gal.
Toluol	35- 40c. " "
Phenol	7- 9c. " lb.
Naphthalene	2¼-2½c. " "

and the current ones are:

Benzol	25-30c. per gal.
Toluol	\$1.50 " "
Phenol	48-50c. " lb.
Naphthalene	8-10c. " "

In the latter part of 1914 the prices soared so that 80c. per gallon for benzol, \$4.50 for toluol, \$1.50 per pound for phenol and 12c. per pound for naphthalene were not uncommon.

These prices led to the erection of the large number of recovery plants which are now connected with every by-product coke oven works and also stimulated the production of synthetic phenol and picric acid as well as T.N.T.

The coal tar dye industry has also had a period of great expansion due to the fact that only the colors made here from strictly American materials could be supplied after the British blockade.

The 16 factories of the coal tar dye industry before the war produced, almost entirely from imported intermediates, annually nearly \$4,700,000 worth of dyes or over one-third of our annual consumption at that time.

Soon after the European War started the skyward jump of prices lead to the establishment of a large number of coal tar dye and intermediate factories.

Many of these had neither the technical knowledge nor business ability and soon fell by the wayside. This was largely due to many plants making the same products which lead to overproduction and to lower prices which they were unable to meet. A more diversified endeavor, so that the field would have been better covered and the ruinous competition avoided, would have resulted in more profitable business for all.

There still is a large turn-over of concerns making dyes and intermediates, due principally to the above cause. While there is no official or accurate list possible of the people engaged in this

industry, the number of plants has increased to about 175, some of whom are quite successful. There appears to be good success in bringing out the newer dyes like those with the Anthracene base, etc.

It seems likely that this industry will be firmly established at the close of the present conflict.

In Europe coal tar is worked up so that the pitch and heavy oils, which constitute 70 to 90 per cent of the tar can be used as fuel.

The pitch in briquettes, etc., and the oils to replace petroleum fuel oils in Diesel engines, etc.

In this country where the briquette industry has not thrived and where fuel oil is so abundant other outlets have had to be found for these products.

We have extended the use of pitch of various consistencies to the wide field of road building and it is admitted that America is far ahead in the use of this material for this purpose.

In the concentrations of ores much use has been made of the heavy oils in the flotation process and in this line again we lead the Europeans in its application and use.

The rapid increase in the coal tar production of the country has required and still requires a large amount of research to develop new uses for products from pitch.

There is certain to be a period of transition after the close of the present conflict that will cause new uses to be found for many of the coal tar products and will lead others to be put, in the major part, to different ones than those of current or pre-war times.

Benzol, toluol and xylol mixed in proper proportions will undoubtedly find a large use in motor fuels.

The steady growth of the industry may be confidently expected.

OPPORTUNITY FOR EXPANSION OF THE BY-PRODUCT INDUSTRY OF COAL AND WATER GAS PLANTS

By WALTER M. RUSSELL

Read at the Gorham and Berlin Meeting, June 21, 1918.

The writer has taken the liberty of slightly modifying the published title of this essay to conform somewhat more closely to the facts as they appear. It is regrettable, but nevertheless true, that the by-product industry in gas manufacturing plants is still in the possibility or opportunity stage. A very few of the gas works in this country have developed a fairly comprehensive system of handling by-products but the great majority still regard the production of gas or gas and coke as the real purpose of their manufacturing processes.

That this is not true abroad is readily apparent by even a hasty glance through the pages of such journals as the *Gas World* or *London Journal of Gas Lighting*. In England particularly great developments in by-product recovery have been successfully in operation for many years.

In this country the usual, well recognized products of the ordinary gas works are gas, coke, crude tar and crude ammonia.

In the larger plants, the crude ammonia is distilled to make a crude impure concentrated liquor containing 12-18 per cent NH_3 , both in free form and combined as sulphides, carbonates, etc. In a very few instances, the crude coal tar is roughly fractionated into three or four cuts.

From water gas manufacture, the only usual by-product is oil tar or water gas tar, which in almost every case is sold in bulk to large refiners.

In the case of small and medium sized gas companies, the above simple products are probably all that could profitably be worked up, but there are many large gas works where great opportunity for expansion in by-product manufacture exists. In these plants the following products may well be considered, in addition to gas and coke:

Ammonia Products	{ Aqua Ammonia Ammonium Sulphate Ammonium Nitrate
	Cyanogen
Tar Products	{ Light Oils Carbolic Oils Creosote Oils Pitch
Light Oil Products	{ Benzol Toluol Solvent
	Sulphur Sulphuric Acid

In the fall of 1917, the Providence Gas Company made a contract with the H. Koppers Company for a battery of coke ovens, designed to operate as gas ovens heated by outside producers, or as coke ovens heated with part of the coal gas produced. No separation of rich and lean gas is to be made in either case. The combination feature is only a safety measure, as it is expected to utilize producer gas entirely for heating the ovens. There are forty ovens in the battery, and the amount of coal carbonized daily will average about 700 tons with 90-100 tons additional gasified in the bituminous coal producers.

The consumption of such a large amount of coal, for a gas works, made it imperative that careful consideration be given to by-products, and the writer, as Chief Chemical Engineer for the Company, has spent the past six months in developing the possibilities in that line and determining the relative importance and financial value of the various products. A detailed study of many plants and processes has been made and while decision has not been reached in all cases, construction is now under way on plant for the production of several important products.

In the following pages, a more or less comprehensive but brief survey will be made of the various by-products and their production that have been considered in our work or are possible in any good sized plant or combination of small plants.

AQUA AMMONIA

Ammonia is produced in coal gas plants from distillation of gas coal and is recovered as a weak solution of free NH_3 and a variety of compounds of ammonia, in water. These crude liquors are of very complex character, often containing the following substances:

A	{	Free Ammonia	B	{	Ammonium Sulphate
		Ammonium Carbonates			" Sulphite
		" Sulphide			" Chloride
		" Hydrosulphide			" Ferrocyanide
		" Cyanide			

The compounds under A are all volatile when the solution is boiled; those in B are not volatile no matter how long the solution may be boiled. These latter compounds are termed "fixed" salts and require decomposition with lime or an alkali to render the NH_3 available.

The liquor as usually obtained in a coal gas plant contains from one to two per cent of total NH_3 , by weight.

The amount of ammonia which is recovered in gas works practice varies largely. In the smaller plants, the yield runs from $2\frac{1}{2}$ to 5 pounds of NH_3 per ton of coal. In a plant large enough to warrant the installation of an aqua plant, a yield of from 5 to 6 pounds per ton should be expected. This yield is greatly affected by the type of carbonizing plant in use. Generally speaking, a plant running with high heats, high yield of gas and small charges will make less ammonia than one using moderate heats, a yield of not more than 5 feet per pound of coal and heavy charges. For the same reasons, the gas from vertical retorts usually contains more ammonia than that from horizontal retorts. Many large works regularly obtain a yield of 6 pounds of NH_3 per ton of coal carbonized and with a yield of anything under 5 pounds, an investigation will generally bring to light opportunities for increasing this yield.

In small works this liquor is often wasted. When the consumption of coal is more than 3000 tons per year, it is distinctly worth while to save this liquor and concentrate it to 12-16 per cent NH_3 , when it may be sold to large refineries at a fair profit.

In any works where the daily consumption of coal is over 300 tons, the production of aqua ammonia offers a very attractive field. The plant is simple to operate and not particularly costly. The following description covers the essential details of an aqua plant such as is built by The Gas Machinery Co. There are many designs of ammonia stills and purifying apparatus in existence but this plant is representative of the general principles.

The apparatus consists mainly of a fixed and volatile still, wherein the liquor is freed from its ammonia, a preheater and purifier for the liquor and a train of purifying apparatus for the gas with a final absorption apparatus for absorbing the pure NH_3 gas in distilled water.

The accompanying cuts (Fig. 1 and Fig. 2) show diagrammatically the arrangement of the various parts of the complete plant.

The ammonia liquor as produced in the plant is pumped into an overhead feed tank, from which it flows into the preheater. The upper sections of this apparatus are equipped with internal bubbling hoods of the usual well known type and are also provided with internal lead cooling coils. In the lower sections of the preheater, live or exhaust steam is admitted to horizontal tubes, over which the incoming liquor flows and is highly heated, expelling a large part of the CO_2 , H_2S and other gaseous impurities, which rise through the upper sections, and by means of the bubbling hoods, the NH_3 which is driven off by the hot sections is reabsorbed, while the impurities pass out through a small scrubber fed with a little water. The upper sections are kept cool with water in the cooling coils, which assists in promoting the absorption of ammonia.

The hot liquor freed from most of the impurities flows through a deep seal into the top of the volatile still, where it flows down through a series of bubbling still sections, meeting steam and ammonia vapors on their way to the condenser, and being heated by these vapors and thus giving off all the volatile and free ammonia contained in solution.

At the lower part of the still is a liming chamber, where the fixed ammonia salts are decomposed with lime and the NH_3 is freed. The liquor flows from the liming chamber to the fixed still, where the fixed ammonia which has been freed in the lime chamber is boiled off.

Steam is admitted into the last section of the fixed still and passes up through all the sections of the two stills, driving off the NH_3 and carrying it along to the entrance to the reflux condenser.

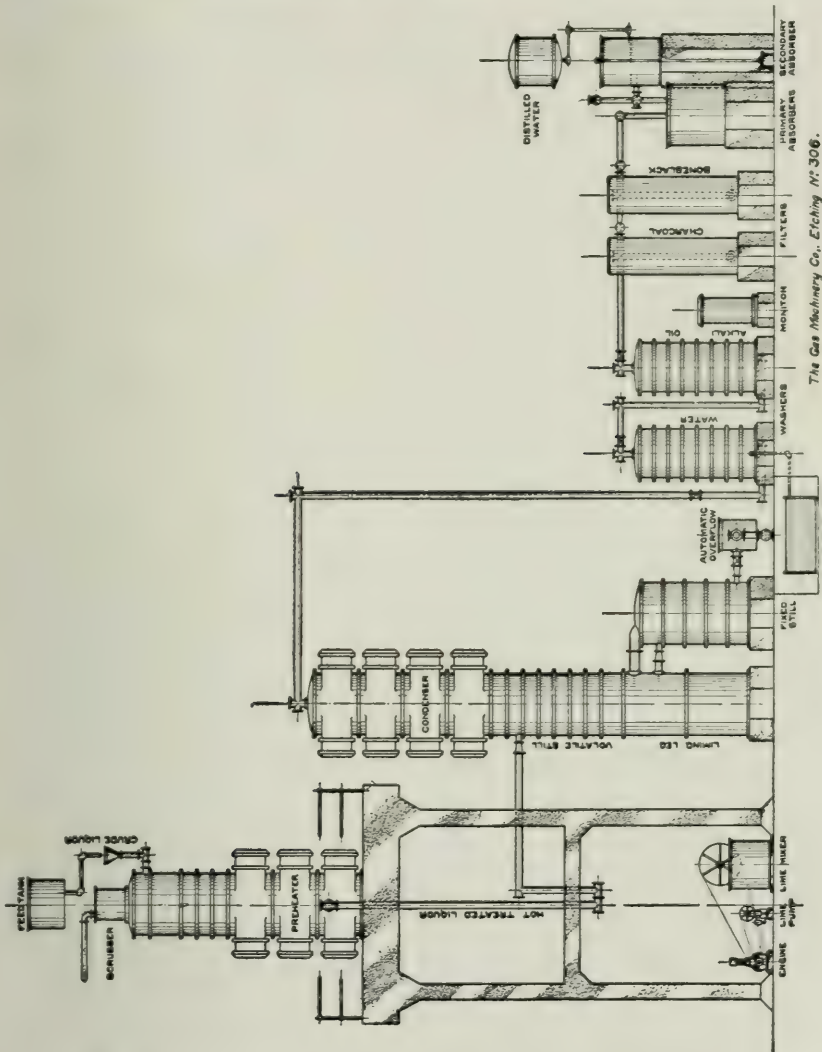


FIG. 1.

The hot spent liquor is discharged from the bottom of the fixed still to the sewer.

The reflux condenser consists of several sections of horizontal

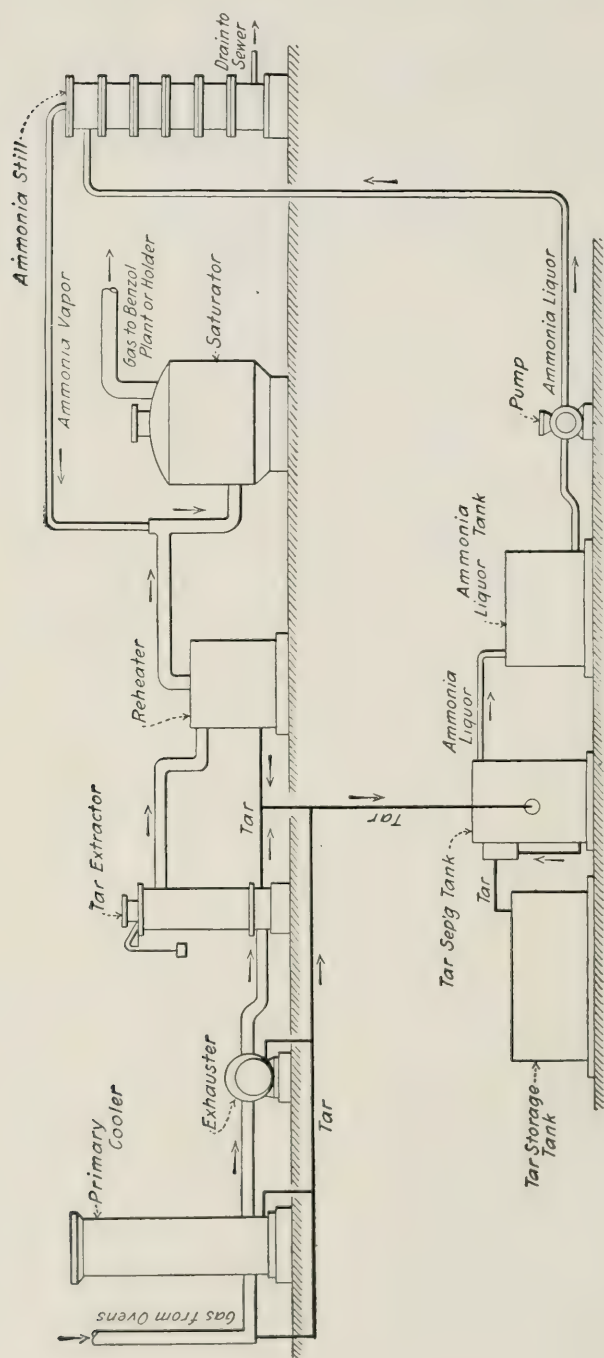


FIG. 2.

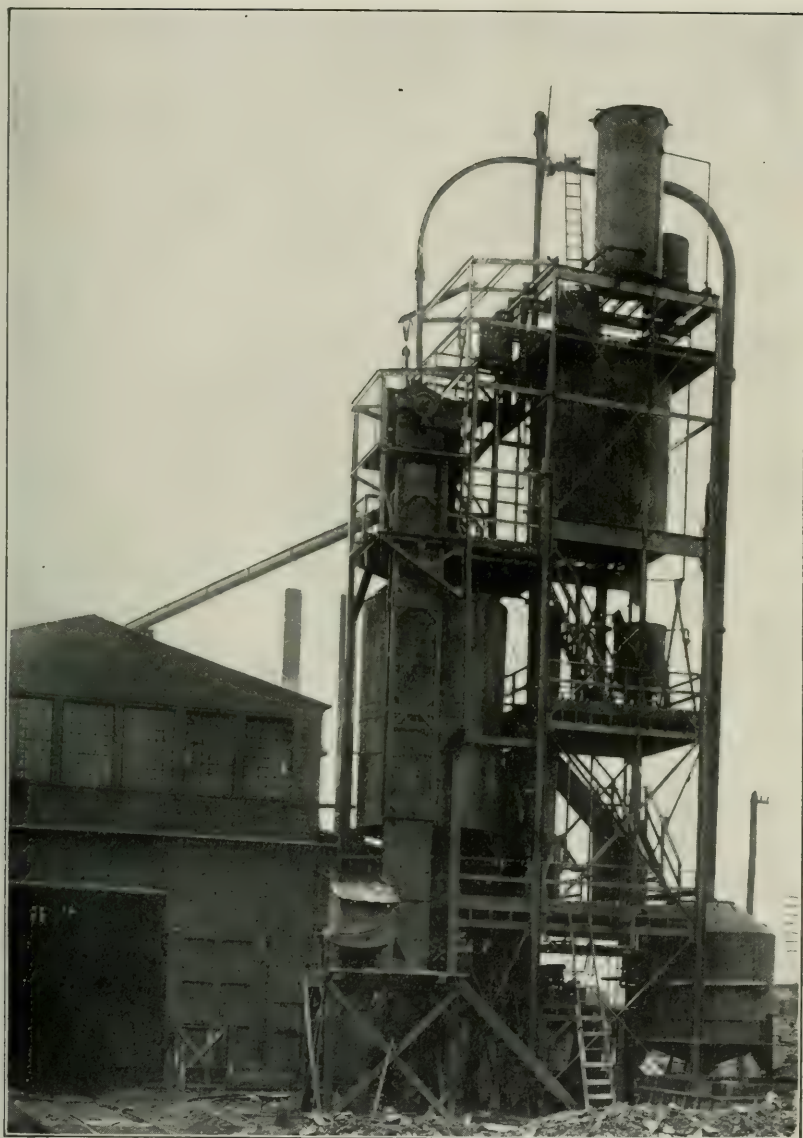


FIG. 3.

cast iron tubes, exactly similar to the preheating sections. In place of steam, however, cold water is circulated through the tubes. The vapors entering the reflux condenser consist of large amounts of steam carrying ammonia along with them. The purpose of the reflux condenser is to get rid of the larger part of the water and cool the ammonia gas to about 140° .

The ammonia vapors pass through a water washer, where they are exposed to the washing action of a small stream of water passing down through a series of bubbling sections. The water dissolves practically all of the H_2S and CO_2 remaining in the vapors. The resulting liquor runs into a drip tank, from which it goes back to the liquor well for retreatment. The washer sections are kept cool with lead cooling coils.

In the alkali washer the ammonia vapors are bubbled through a solution of caustic soda to arrest any impurities which may possibly pass the water washer.

The oil washer is fed with a light engine oil which absorbs organic compounds. The construction of the oil, alkali and water washers is the same as the bubbling sections of the stills.

Two pairs of filters are provided: two charged with charcoal and two with boneblack, which serve to absorb all coloring matter from the ammonia gas.

The vapors of ammonia which have been purified, cleaned and cooled pass next into an absorber, kept cool with circulating water in cooling coils, wherein the NH_3 is absorbed in distilled water, forming a highly concentrated aqueous solution, containing 29.4 per cent of NH_3 by weight; specific gravity, 26.4° Bé.

Aqua ammonia has a large use in the industrial arts and is the source of the anhydrous ammonia used in ice machines.

The price of aqua is now fixed at 13c. per pound of NH_3 , although in times past it has been much higher than this and will doubtless be higher in the future.

A coal gas plant carbonizing 300 tons of coal per 24 hours, recovering a net amount of 5 pounds of NH_3 per ton of coal in the form of aqua ammonia, would have an income and operating sheet about as follows:

Income:

Ammonia 300 tons x 365 days x 5 lbs. at 13c..... \$71,175

Operating Expense:

Fuel for Steam for Distillation at \$6 ton....	\$6,000
Lime (average) at \$10 ton.....	600
Cooling Water, Cost of Pumping.....	325
Distilled Water, 250,000 gals. at cost of distillation	1,000
Caustic, Oil and Charcoal.....	600
Labor	8,400
Supervision and Laboratory.....	3,000
Miscellaneous	1,000

Total	20,925
-------------	--------

Gross Profit..... \$50,250

From the above must be deducted interest on investment, taxes and a fairly high depreciation charge, leaving, however, a very handsome net profit.

AMMONIUM SULPHATE

The early processes for the formation of ammonium sulphate all depended on treating the ammoniacal liquor obtained by condensing coal gas and were strictly indirect processes, the liquor being distilled and the NH_3 gas neutralized in an acid bath.

At the present time a company would hardly consider the installation of such a process, as the Koppers semi-direct process offers so many superior advantages.

This process was introduced in the country only a few years ago but has rapidly gained favor and is installed in practically every new coke oven plant which is built.

In this process the coal gas passes through primary coolers, where it is cooled to about $38^\circ\text{--}40^\circ\text{C.}$; then through an exhauster to a tar extractor usually of the well known P. and A. design. The cooled gas then passes into a reheater, where it is heated by means of indirect steam coils to about 65°C. The hot gas then passes into a bath of ammonium sulphate solution, containing 5 per cent free sulphuric acid, where the NH_3 in the gas is neutralized, form-

ing crystalline sulphate of ammonia. Fresh acid is constantly supplied to maintain the proper acidity of the bath.

The crystallized salt is withdrawn to a centrifuge, where the free acid is forced out and the sulphate is washed with small amounts of water, the acid and water washings returning to the saturator and the sulphate being bagged for shipment.

As the gas is reheated after condensation, it is capable of absorbing water from the acid bath and the strength of the bath and the heat of the incoming gas are so regulated as to constantly keep the bath in a state of saturation, so that all sulphate as formed is immediately thrown down in crystalline form, the hot gas carrying away the excess of water from the bath and maintaining a saturation.

The tar and ammonia liquor from the condensing system flow to a tar separating tank, the tar going to a tar storage and the liquor to a liquor storage. From here it is pumped to an ammonia still, where by means of live steam and lime, all the ammonia is driven off as free NH_3 and accompanied by some water vapor is re-introduced into the system at the entrance to the acid saturator.

As usually made, sulphate by this process is a white crystalline salt, containing 25 per cent NH_3 from .8 to 1.5 per cent moisture and not over .5 per cent of free acid.

This process is simple and positive and has attained great success in this country.

AMMONIUM NITRATE

At the present time there is a great demand on the part of the Government for pure ammonium nitrate. In spite of the fact that immense synthetic ammonia and nitric acid plants are under construction, the Government is desirous of obtaining all the ammonium nitrate possible from every source and has fixed a price of 15c. a pound for it.

Any plant producing aqua ammonia may well consider the manufacture of ammonium nitrate. The apparatus is simple and not very costly, and the process is fairly easy to control. Strong nitric acid is added to the aqua ammonia from the absorber until a saturated solution is obtained, which must then be evaporated, run into a crystallizer and the crystals withdrawn with a suction

filter and dried. The process of nitration must be done in a vat supplied with aluminum cooling coils to keep down the temperature of the bath to avoid loss by overheating and formation of fumes.

The great drawback to the manufacture of nitrate in an aqua plant is the necessity for handling carboys and the difficulty of obtaining nitric acid. However, the net profit from the ammonium nitrate would be about 50 per cent more per pound of NH_3 than if it were sold as aqua ammonia and even greater when compared to sulphate.

CYANOGEN

Potassium and sodium ferrocyanide are the base of a great variety of cyanogen products, one of the most important being Prussian blue. Potassium cyanide has a large use in gold ore extraction.

Cyanogen exists in coal gas to the extent of from 1 to 2 pounds per ton of coal carbonized, depending on the size of charges and the temperature of combustion. Its removal from the coal gas is advantageous for two reasons: Its removal will increase and prolong the activity of the purifying oxide, as otherwise it enters into combination with the iron in the monoxide. Secondly, its removal in a form suitable for sale to chemical plants is a profitable commercial proposition.

The system of cyanogen recovery most suitable for the average gas works is the Bueb process as built in several plants in this country by the Bartlett-Hayward Co.

In this process the coal gas, after passing through a tar extractor at a temperature of 100° , is further cooled to about 70° and is then treated in vertical centrifugal scrubbers or washers with a solution of ferrous sulphate admitted through a carefully regulated valve and flowing in the opposite direction to the upward flow in the scrubber. In this washer the following reactions take place:



The amount of ammonium sulphate produced is dependent upon the quantity of iron supplied. A slight excess of iron is always used, so that in calculating the amount of sulphate formed, 1.75 pounds per pound of cyanogen in the gas per ton of coal is the figure which will be found to be in line with actual recovery practice.

The ammonia combined with the iron in the cyanogen is very closely 25 per cent of the recovered cyanogen. This ammonia is paid for when the press cake is sold. The ammonium sulphate formed may be delivered by the presses as ammonium sulphate or it may be treated in an aqua ammonia plant or it may be combined with the Koppers semi-direct sulphate process, depending on local conditions.

The crude sludge which leaves the scrubbers contains, besides the insoluble precipitate of ferrous-ammonium-ferrocyanide, free ammonium compounds, ferrous sulphite and ammonium sulphate in solution. This material is delivered to a neutralizer, where it is treated with sulphuric acid, which fixes all free ammonium compounds as sulphate and converts the precipitated ferrous sulphide to soluble ferrous sulphate.

The neutralized sludge is then heated to 170° with steam and is dropped into a tank and then filtered in filter presses, the filtrate then going to a precipitator, and the press cake is disintegrated in a wash tank with hot water for several hours, by means of which treatment soluble iron, acid and ammonium sulphite is washed out. The content of tank is then again filter pressed, rendering the cake ready for final shipment, and the wash water is used for making up fresh copperas solution.

The sulphate liquor in precipitator is next treated with strong ammonia liquor, which will throw out any soluble iron compounds and will produce sulphate of ammonia. The sulphate of ammonia liquor, as stated above, may be utilized by direct evaporation to the crystallized salt or by treatment to aqua or utilized in the Koppers sulphate saturator.

The sulphate produced by direct evaporation is of a higher quality as to concentration and color than the best commercial grade of this material.

The sulphide residual remaining in the precipitator is filter pressed, obtaining the iron in a form suitable for mixing with the

purifying material or oxide, the filtrate returning to the precipitator.

The following figures serve to illustrate the disposition of the ammonia in this process, as having relation to the problem of ammonia recovery as a whole, where conditions are such that one pound of cyanogen per ton is recovered:

	Per ton of coal carbonized,
Ammonia in original gas works liquor as sulphate.....	.60 lbs.
Ammonia as sulphate returned from Bueb process.....	.48 "
Ammonia combined with cyanogen and press cake.....	.22 "
Balance of ammonia.....	4.70 "
Total ammonia in the coal.....	6.00 "

All of the ammonia except the ammonia combined in the press cake could go either to sulphate or to aqua. Therefore:

$$6.00 - .22 = 5.78 \text{ lbs. NH}_3$$

would be recovered in the aqua ammonia or could be converted into sulphate in a semi-direct process as desired.

The following estimate of the income and operating expense of the plant has been based on a consumption of 300 tons of coal per day, recovering one pound of cyanogen per ton of coal carbonized and figuring cyanogen at 40c. per pound, which is a fair price under present conditions, sulphate at 4½c. per pound, combined ammonia at 8c. per pound, copperas at 1c. per pound and sulphuric acid of 66° Bé. strength at \$40 per ton delivered at plant.

The price of sulphuric acid may seem a little high but it is used in rather small quantities and it is doubtful if it could be purchased for much less at the present time, although in normal times, of course, this would be an exceedingly high figure.

The consumption of copperas has been found in actual practice to be about 3.565 pounds per pound of cyanogen recovered and the amount of acid, .75 pounds per pound of cyanogen recovered.

INCOME AND OPERATING DATA—CYANOGEN RECOVERY

Income:

300 tons coal x 1 lb. CN at 40c. per lb.....	\$120.00
Combined Ammonia at 8c. per lb.....	6.00
	\$126.00

Operating Expense:

Chemical Engineer in charge.....	\$6.00
Operators, 3, at \$4.00.....	12.00
Laborers, 2, at \$3.50.....	7.00
Copperas—300 lbs. x 3.565 lbs. at 1c. per lb...	10.70
Acid—300 lbs. x .75 lbs. at 2c. per lb.....	4.50
Steam—Total at 45c. per M lbs.....	10.00
Miscellaneous Expenses.....	2.00
Total per day.....	52.20

Gross Profit..... 73.80

From this must be deducted interest, taxes and depreciation, leaving, however, a very satisfactory net profit.

TAR PRODUCTS

The wonderful ramifications of the tar distilling industry are not for the gas works operator to follow. They require a vast specialized knowledge, an elaborate plant and a highly organized selling program for their successful prosecution.

Neither is the gas engineer required to sit idly by while the great semi-monopolistic tar interests take over his raw material at a nominal sum and transmute it into many times its "residual" value.

Even a medium sized gas works may well consider apparatus and plant for the simple refining of coal and water gas tar. The notable work of Mr. Alan C. Whitaker of the Atlanta Gas Light Co. is an excellent case in point where a gas company, no longer satisfied to dispose of its tar output at a nominal amount per gallon, installed simple equipment and established a wide and highly profitable market for its products.

There are practically no uses for crude tar on account of the ammonia liquor or water which is always present. Tar can be burned but this is not a proper use for tar except in very special or exceptional cases. Tar oils are highly successful in Diesel type engines and this outlet offers interesting possibilities.

Tar stills for gas works should naturally be moderate in size to accommodate the volume of tar daily or weekly accumulated.

Horizontal intermittent stills are greatly favored in this country, while continuous stills have very lately given encouraging results.

The still should be set in a common brick boiler setting with a protecting arch under the still bottom, and may be fired with coke, coal or gas.

The simple fractions which it is practicable to make in gas works tar plants would be:

Light Oil.....	1%- 4%	110°-200° C.
Carbolic Oil.....	5%-15%	200°-240° C.
Creosote Oil.....	15%-35%	240°-315° C.
Pitch	50%-80%	Residuum

The still is provided with a long worm or condensing coil, frequently being made up as a rectangular coil in an open tank. The first step is dehydration, which must be done slowly and with great care to avoid foaming, boiling over or explosion. In the case of coal tar, the water which comes over is impregnated with ammonia, which may be returned to the ammonia storage well and will help to swell the monthly account of "Pounds of NH_3 per ton of coal."

Dehydrated tar can be used for a good many purposes and has a market value much in excess of crude tar. It has large use—as a road treatment, for tar paper, waterproofing, etc.

The light oil contains benzol, toluol and solvent naphtha. If the gas works has a toluol plant, the light oil may go direct to it. Otherwise it may be accumulated and sold or used for cutting pitch for various products.

Carbolic oil will contain the tar acids and naphthalene. Naphthalene may be separated by cooling or the tar acids may be extracted by agitation with alkalies and then freed by treating with sulphuric acid. From these tar acids, phenol and cresol is obtainable.

Creosote oil has a large use as a preservative of wood for paving blocks, posts, ties, shingles, etc.

Pitch may be of very varying consistency: soft, medium or hard. As a treatment for roofing felt, surface treatment of roads, filler in block pavements and for waterproofing, soft pitch is used. Medium pitch is used for roofing and as a binder in briquetting. Hard pitch is used for electric carbons, foundry supplies, clay pigeons, insulating compounds, etc.

BENZOL, TOLUOL AND SOLVENT

No description of gas works by-products would, at the present time, be complete without at least a brief discussion of benzol and its allied products.

There has recently appeared such a large amount of detailed description of benzol and toluol recovery that only the main points will be touched upon in the following paragraphs.

It has been authoritatively stated that before the war is over, gas works in cities of only 100,000 population will be required to strip the light oil from their gas output. This would ordinarily mean an output of from 1½ to 2 million feet per day. Five hundred gallons of light oil per day is now regarded as a small output and probably represents something near the lower limit of practical size. This would correspond to about 1,500,000 cubic feet of daily gas output.

A plant of this size could profitably strip its gas of its light oil and run the benzolized wash oil through a wash oil still, separating the light oil for shipment to some central refinery.

A plant having a production of 2,000 gallons of light oil per day could afford to add a crude still to produce crude benzol, toluol and solvent. Such an amount of light oil would correspond to a little over 5,000,000 cubic feet daily gas output.

The exact point in size at which a benzol plant can profitably take up the production of pure products is not very readily determinable, but it is probably safe to say that a gas works sending out 10,000,000 cubic feet or more daily could profitably engage in the production of pure products. As there are very few plants of this size, and in these arrangements for toluol recovery are already under way, this description will cover only the production of crude products, as it could be practiced in the ordinary gas works.

ANALYSIS AND YIELD OF LIGHT OIL FROM VARIOUS SOURCES (S.P.E.R.R.)

ANALYSES

Sources.	Per Cent Benzene.	Per Cent Toluene.	Per Cent Solvent.	Per Cent Wash Loss.	Per Cent Res. Below 200°.	PARAFFINS IN BENZENE.		PARAFFINS IN TOLUENE.	
						Per Cent of Light Oil.	Per Cent of Benzene.	Per Cent of Light Oil.	Per Cent of Toluene.
Coal gas, horizontal retorts.....	58.8	12.8	13.1	5.7	8.4	0.7	1.19	0.5	3.01
Coke oven gas, rich.....	52.2	18.6	11.0	8.8	0.1	0.3	0.57	0.0	0.00
Coke oven gas, lean.....	55.7	12.6	11.2	7.4	12.8	0.3	0.54	0.0	0.00
Coke oven gas, run of oven.....	44.3	18.2	11.2	11.6	14.7	0.0	0.0	0.0	0.00
Water gas.....	39.9	21.6	14.1	11.4	12.4	0.5	1.25	0.1	0.46

YIELD

Gals. per M. cu. ft. original gas

Sources.	Yield		
	Light Oil.	Benzene.	Toluene.
Coal gas, horizontal retorts.....	0.403	0.237	0.031
Coke oven gas, rich.....	0.3461	0.181	0.064
Coke oven gas, lean.....	0.3214	0.178	0.040
Coke oven gas, run of oven.....	0.3600	0.159	0.066
Water gas.....	0.508	0.203	0.110

Practically all of the work which has been done on benzol and toluol in this country has been done by the H. Koppers Company and the writer is naturally indebted to their engineers for information regarding the processes. In a recent issue of the *Gas Age*, Dr. Sperr of the Koppers Company gave the following table as typical analyses of various light oils:

The method employed in most plants is to pass the purified coal or water gas through a very tall tower scrubber filled with wooden trays. A petroleum oil, known as straw oil, is pumped to the top of this scrubber and runs down over the trays, absorbing practically all of the hydrocarbon vapors in the gas, which are grouped under the term "light oil," including benzine, toluene, xylene, mesitylene, pseudocumene, naphthalene, etc., with other hydrocarbons, which later have to be gotten rid of in the production of pure products. The circulation is maintained at such a rate as to cause the benzolized wash oil to contain 3-4 per cent of light oil.

The enriched wash oil is passed through a continuous still, supplied with live steam, which drives the light oil out of the wash oil. The steam and light oil vapors are condensed and separated and the light oil is stored until needed for refining or for shipment.

The hot, debenzolized wash oil is cooled and again pumped over the scrubbers.

The construction of the still conforms to the well-known type of continuous bubbling column type. The system of heat exchange has been ingeniously worked out by the Koppers Company in their plants as follows: The hot oil from the still flows into a tank containing coils, around which it is caused to pass a number of times, losing most of its heat and flowing thence to a tank, from which it is drawn for further scrubbing; if necessary, first passing through a pipe coil condenser, sprayed with water.

The circulating coils contain benzolized oil on its way to the still. The benzolized oil on its way to the still passes first to the vapor and oil heat exchanger, where it acts as a condenser for the light oil and steam vapors from the still and absorbs heat enough to raise it to about 50° C. From here it goes to the oil heat exchanger, where it absorbs further heat from the wash coil leaving the still, gaining in temperature to about 100° C. Before entering the still, the oil passes through a superheater, where, by means of steam, it is further heated to about 140° C.

At the upper part of the still there is a short series of small

bubbling sections, which act to scrub out any oil mechanically carried over, and also to a slight degree as a reflux condenser.

The light oil from the separator flows to a storage tank, where it accumulates until a sufficient quantity is on hand for a charge for the crude still.

A convenient size for a crude still is 10,000 gallons, although sizes of from 6,000 to 14,000 are known. The larger stills give better fractionations than are possible in smaller sizes. From the body of the cylindrical still, a tall column rises, consisting of a series of bubbling cup and seal distilling sections, surmounted by a dephlegmate or water cooled tubular cooler, which condenses the heavier vapors, which run back to the still, and allows the light vapors to pass on to a condenser, which is water cooled and condenses the various products to liquid form. The condenser is supplemented by a separator, which serves to separate the water from the oil, where direct steam is used in driving off the higher boiling fractions, such as xylol and naphtha.

After charging a crude still, steam is turned onto the steam coils and the temperature gradually raised until it reaches the neighborhood of 176° F., when benzol begins to come over. The distillation proceeds for a long period with a very slow gradual rise in temperature to about 180° F., from which point there is a fairly rapid rise to 212° F., as additional steam is turned on. At this point the crude benzol fraction may be cut off and the crude toluol fraction started.

The distillation now proceeds more rapidly, the temperature rising from 212° F. to 248° F., when the crude toluol fraction may be considered as completed.

Considerable latitude exists in the manipulation of time and temperature at the points of changing fractions and a skillful operator can largely increase the toluol fraction by careful control of the still at the critical points.

Following the crude toluol cut, the temperature is raised as rapidly as possible until no more oil comes off, when direct steam may be used to free the wash oil residue from the last traces of heavy solvent.

At the present time, no separation is made after the toluol cut, the xylol and naphtha being classed as one product, "crude solvent."

The wash oil remaining in the still contains naphthalene and

on cooling it separates out and in large plants may be bagged and sold.

The yield in benzol and toluol of light oil from various sources varies considerably and there is no set rule for computation. The following figures have been given by Mr. Ramsburg as average yields under the Koppers system in coke oven practice:

YIELD FROM 1000 GALLONS CRUDE LIGHT OIL

Crude Benzol	690 gals.
Crude Toluol	150 "
Crude Xylol	40 "
Solvent Naphtha.....	45 "
Wash Oil Containing Naphthalene....	75 "

The crude products are purified by treatment with sulphuric acid and alkalies and finally very carefully distilled to make pure products. This class of work can be profitably carried on only in the very largest gas works and for reasons previously stated will not be discussed in detail.

At the present time, there is no question of profit to be derived from operating a benzol or toluol plant, as it is the duty of every gas company to place itself unreservedly in the hands of the Government and to produce every gallon of these products that is desired.

However, many plants are installing their own more or less complete apparatus or allowing Government owned plants to be erected, and it is a pertinent question as to the status of this industry after the war.

In this connection it may be briefly noted that a natural mixture of pure benzol, toluol and solvent is a splendid motor fuel, having 20 per cent more power per unit than gasoline and being furthermore absolutely uniform in quality. Mixtures of benzol, gasoline and alcohol also offer wonderful opportunities for gasoline substitutions. An immense amount of research and experimental work is now being done in this direction, and we may expect large commercial developments in the coming year.

For obvious reasons it would be inadvisable to discuss detailed cost figures for light oil refining at the present time. However, it may be proper to state that after the war, with conditions as we are able to forecast them, it will be possible to produce and sell

a motor spirit at the price of gasoline, with a profit, including interest charges of 10c. per gallon, which should serve to reassure the managements of plants who have made more or less extensive investments in benzol and toluol recovery plants.

SULPHUR AND SULPHURIC ACID

In the purification of coal and water gas, a compound of ferric oxide and shavings or planer chips is used to remove hydrogen sulphide from the gas. The ferric oxide unites with the hydrogen sulphide to form sulphide of iron. When this process has continued for a period, the iron becomes inactive and the material is exposed to the action of air; whereupon the air revivifies it, oxidizing the iron sulphide, forming oxide of iron and setting free sulphur. The material may then be put back in service. This alternate fouling and revivifying goes on for a long period until eventually the purifying material contains 40-50 per cent. of free sulphur.

In the case of coal gas, the spent oxide often contains six per cent or more of cyanogen, which gives it some value, but in the case of water gas and in many coal gas plants, spent oxide is considered to be of no value and is thrown away.

In small works the value of the sulphur is small and unless several plants combined to work up the oxide together would not be financially attractive.

When, however, the amount of spent oxide amounts to 2000 tons or more per year, a combined sulphur extraction and sulphuric acid plant offers a very attractive opportunity.

The process of sulphur extraction for spent oxide from gas works is the work of Mr. Arthur Given of New York City, who has designed, built and operated successfully plants for this purpose. The plant consists of an extractor, a solvent still, solvent condenser and suitable storage tank, pumps and various accessories.

A convenient size is for 20 tons of oxide per charge. The solvent proposed and successfully used by Mr. Given is carbon disulphide but benzol is much cheaper and while less powerful than bisulphide, as a sulphur solvent has been found to be satisfactory.

In the operation of the plant 20 tons of spent oxide are charged into the extractor and the still is filled with solvent. By means of steam coils in the still, the solvent is boiled and rises to the con-

denser placed above the extractor. The condenser is water cooled and the condensed solvent runs down to the extractor, filling it and siphoning out through an equalizing chamber back into the still, carrying dissolved sulphur with it. It is redistilled continuously, so that the oxide is treated with fresh clean solvent until practically all the sulphur is dissolved out. Steam is then shut off from the still and turned on to coils in the extractor, driving off all benzol from the oxide remaining in the extractor. This solvent passes through the condenser to a storage tank. While the extractor is being discharged of oxide, the solvent in the still is driven off with steam and when all the solvent is off, the temperature is raised until the sulphur melts and it is then run off into pans, where it solidifies in cakes ready for breaking up into lumps.

The extracted oxide is lightened by the addition of a small amount of new shavings and iron oxide and is then ready for use again.

The crude sulphur contains 5-10 per cent of tar dissolved from the oxide. It may be used for acid making or, if desired, it may be purified to any desired degree by recrystallization.

In designing a sulphuric acid plant to utilize this crude sulphur, about 20 per cent must be added to usual chamber space to take care of the dilution of the gases due to the formation of carbon dioxide from burning the tar with the sulphur. Fourteen cubic feet of chamber space have been figured as ample per pound of this sulphur burned per 24 hours.

The sulphur may well be burned in an ordinary hand fired sulphur burner. The general design of the plant would be entirely in accordance with standard acid practice for plant of this size, and might consist of the usual Glover tower, three chambers and Gay Lussac tower. By recirculation, this plant could produce 60° Bé. acid, which would be entirely suitable for the production of ammonium sulphate from the coal gas. If it were necessary to make 66° acid, a concentrating tower would be required.

Some question might be raised among practical acid men as to the possibility of trouble from the small amount of tar in the sulphur. However, the best answer to such an objection is that this extracted sulphur is being used successfully to make acid.

In figuring an income and operating sheet for such a plant, a value of \$25 per ton of 60° acid is not too high under present

conditions and if taken in consideration of a plant requiring considerable amounts of acid for making sulphate of ammonia, etc. The value of the recovered oxide for purifying properties is practically the same as new oxide and is worth easily \$12 per ton.

A coal or water gas plant producing 2000 tons of spent oxide per year of 45-50 per cent free sulphur should be able to recover about 900 tons for producing acid. About 9.5 tons of 60° acid would be produced daily from this amount of sulphur, or 3465 tons per year, together with 1100 tons of recovered oxide. An income and operating sheet would be about as follows:

Income:

3465 tons Acid at \$25 per ton.....	\$86,625
1100 tons Oxide at \$12 per ton.....	13,200
	\$99,825

Operating Expense:

Labor in Sulphur Plant.....	\$9,760
Solvent Loss.....	2,000
Power, Water and Steam.....	5,000
Handling Oxide.....	800
Labor in Acid Plant.....	12,550
Nitrate of Soda.....	3,000
Water and Steam.....	1,800
Power	1,800
Miscellaneous	1,800
	38,510

Gross Profit..... \$61,315

As a result of the operation of this plant, a gross profit of \$61,000 per year might be expected, which would amortize it in a reasonable time. After the war, when acid is selling at more competitive prices, the opportunity for producing very cheap sulphur would permit the operation of this plant at a profit even in competition with large acid producers.

CONCLUSION

From the above brief descriptions of various products, it is possible to make in coal and water gas plants, one cannot help but

realize that there is a great field of endeavor that is yet untouched by the great majority of manufacturers.

That there is an awakening to this on their part is apparent however, to those who are in touch with the manufacturers of apparatus for the chemical trade, as they are more and more frequently receiving interesting inquiries from large and medium sized gas companies all over the country relating to the possibility of installing one or more of these attractive by-product manufacturing systems.

Without doubt the next ten years will see a wonderful new development along these lines.

SYNTHETIC PHENOL

By A. G. PETERKIN

Read at the Gorham and Berlin Meeting, June 21, 1918.

It is difficult to estimate the quantity of any of the products from coal tar which is available, because on the one hand, the production of tar is changing from day to day, due to the continued increase in the number of coke ovens and on the other hand, its consumption for fuel purposes is affected by greater or less difficulty in obtaining supplies of coal. It is safe to say, however, that it would not be practical or even possible to-day to make more than five to six million pounds of phenol per year available from this source.

The United States used before the War some 5,000,000 pounds of phenol per year, the consumption being divided between pharmaceuticals, resins of the Bakelite type, dyestuff intermediates, and the explosive, picric acid. At the beginning of the War, the demand immediately increased, due to the increased manufacture of picric acid. The French Government particularly, became a large customer of manufacturing concerns in this country, both for phenol and picric acid. The production at the time just before the entrance of this country into the War had jumped to something like 72,000,000 pounds of phenol per year.

It is likely that 1919 will see a very great increase in the production of phenol in this country. Coal tar as a direct source of phenol is therefore a negligible factor in view of the present demand.

Whatever the merits of picric acid as an explosive, a real objection to its manufacture in such times as these, lies in the relatively enormous amount of raw materials involved, and the necessity for the correspondingly great consumption of our valuable transportation facilities. For example, to make 100,000,000 pounds of Synthetic Phenol requires in round numbers:

Benzol	115,000,000 lbs.
Fuming Sulphuric Acid ($9\frac{1}{2}\%$) ...	280,000,000 "
Caustic Soda.....	180,000,000 "
Lime	42,000,000 "
Limestone	190,000,000 "
Coke	35,000,000 "
Niter Cake.....	42,000,000 "

A total tonnage of..... 884,000,000 lbs.

or nearly nine times that of the finished product, using the generally adopted process and working with fair economy. To say that it is an extravagant process is to put it mildly, but it has maintained itself with considerable obstinacy in the face of many attempts to improve and shorten it.

The illustration shows the old process diagrammatically. It has been described many times, and a bare outline will suffice now. Benzol is sulphonated at temperatures varying from 50° to 70° C. The strongest acid that may be used with economical results in the writer's opinion is fuming sulphuric acid containing $9\frac{1}{2}$ per cent of free SO_3 , the limitation being enforced by the necessity of avoiding the formation of diphenyl-sulphone. Since the composition of the spent acid from the sulphonation is a constant, the amount of sulphonic acid necessary for the completion of the reaction is increased very largely as the concentration of the initial acid is decreased. It has, therefore, not been considered economical to use acid weaker than one containing 98 per cent H_2SO_4 . The figures given above are for the higher concentration. The result of the sulphonation is a solution of sulphonic acid, sulphuric acid and water. The sulphuric acid and water together make a spent acid of approximately 80 per cent H_2SO_4 and 20 per cent H_2O . The solution then contains in round numbers, 60 per cent sulphonic acid and 40 per cent spent sulphuric acid. The sulphonic acid is required in the form of sodium salt. The procedure in all plants, is essentially the same, although many minor variations have been adopted. Slaked lime is placed in the agitators and the mixture of sulphonic and sulphuric acid slowly added during agitation. The sodium salt may be formed by addition of sodium sulphite obtained from the fusions later in the process. When this procedure is adopted, the mixture in the agitators consists of a water solution of sodium benzene sulphonate and a mixture of solid

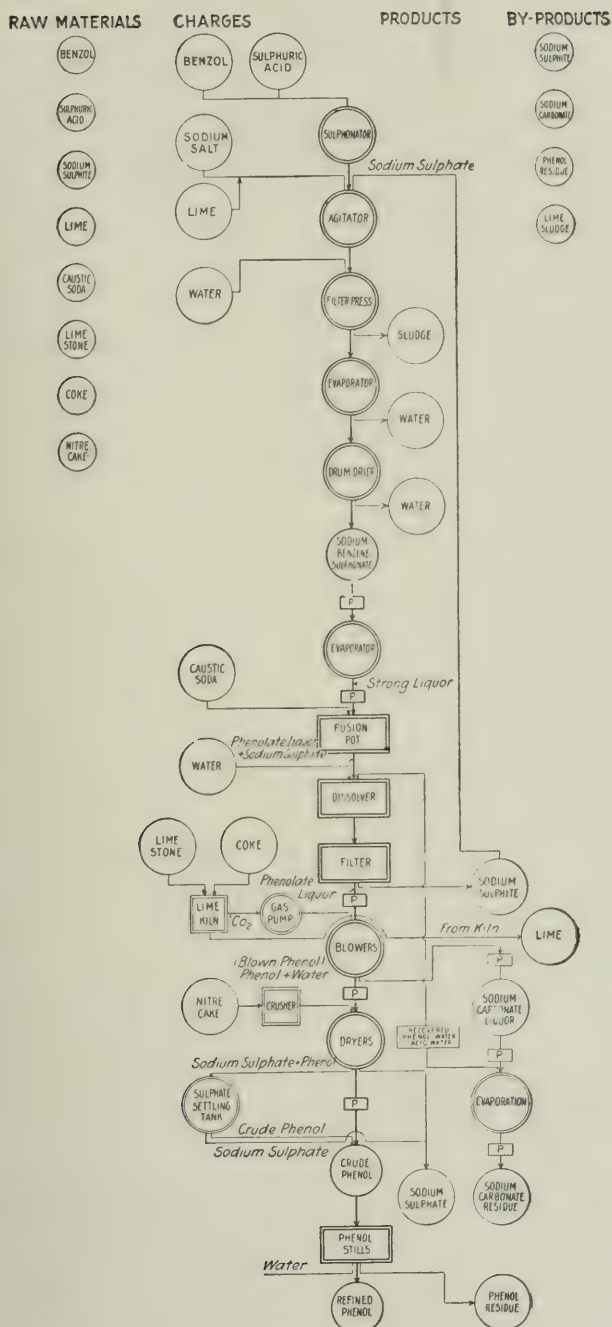


Fig. 1.—Chart showing Process.

calcium sulphite and calcium sulphate. The whole is heated to 115° C. in order to obtain the sulphate in proper crystalline form for filtering, and is passed through the filter presses. The resulting solution of sodium benzene sulphonate contains approximately 12 per cent of the salt and small quantities of calcium sulphate, due to the slight solubility of this material. It is important to remove all calcium salts, both for the sake of the tubes in the evaporators and because of the havoc they cause in the fusion operation. This is accomplished by the addition of the necessary small amount of sodium carbonate and refiltration. Some factories make the soda salt in two steps, adding sodium carbonate to the filtered solution of calcium benzene sulphonate; others add only the amount of lime necessary to react with the sulphuric acid, in making the soda salt in one step, which makes the use of the by-product sulphite difficult, due to the liberation of SO_2 . The 10 per cent solution is evaporated down to the saturation point, and the salt obtained from the syrup by means of drum dryers. The salt, preferably retaining about 10 per cent of water, is fed into melted caustic soda in the fusion kettles, there being about one molecule of soda in excess. The temperature during the fusion is maintained between 320 and 350° , the salt being fed in slowly during the operation.

Three hundred and twenty degrees Centigrade appears to be the critical temperature of the reaction. As the result of the fusion, a light brown liquid mass with the appearance of melted chocolate is obtained, which is poured hot into such an amount of water as will dissolve the phenolate and leave the sodium sulphite in solid form. This is done in vessels marked "Dissolvers," which are provided with stirrers. Only about 10 per cent of the sulphite formed remains in the solution and this amount can undoubtedly be decreased. The phenolate liquor is filtered from the sulphite on open sand filters. The sulphite is agitated with water, separated by means of filter presses, washed free of phenol and marketed as an impure sodium sulphite. A typical analysis of this material is:

Moisture	24.20
Na_2SO_4	7.12
Na_2SO_3	62.30
Insol. in hot H_2O	0.46
$\text{C}_6\text{H}_5\text{ONa}$	0.60

The wash water is used in the dissolvers so that its sulphite is deposited again on the filter beds.

The phenolate liquor is carefully diluted to a gravity corresponding to a phenol content of about 16 per cent. This diluted solution is placed in a series of tanks. Thirty per cent carbon dioxide gas generated from a mixture of coke and limestone is passed through it. These so-called "blowers" are arranged so that the gas may pass from one to another in any direction desired. The strong gas goes first through the almost neutralized phenolate and leaves from a strongly alkaline solution, thus avoiding any possibility of loss due to the vapor pressure of phenol at the temperature of the spent gases involved which is about 50° C. It is not possible to entirely neutralize the phenolate solution by means of carbon dioxide in one operation; at any rate, unless such a large excess of CO₂ is introduced as to transform all the carbonate to bicarbonate, which is undesirable. When the passage of the gas is discontinued the phenol layer contains in solution about 10 per cent phenol as sodium phenolate, while the carbonate layer is free from phenolate but contains approximately two per cent of phenol. The carbonate is completely freed from phenol by means of a steam distillation; a four per cent solution of phenol is obtained in this way. The crude phenol containing 10 per cent of phenolate may be completely acidified with CO₂, by replacing the carbonate solution with water. Niter cake, however, used as an acidifying agent has the advantage of simultaneously removing a large percentage of the water present. The dehydration reduces the water content of the crude phenol from 30 per cent to less than 14 per cent, and relieves the refining stills of a great burden. The crude acid is placed in a simple still from which is obtained a first fraction of water and phenol, a middle fraction of pure phenol and a residue of the more complex phenolic bodies formed in the fusion. The synthetic phenol produced is exceedingly pure; it is comparatively easy to obtain material melting at 40° C. Redistillation gives a product melting at 40.6°. The true melting point of pure phenol is in our opinion 40.8° C.

The great economies possible in the process are obviously to be made in the cutting down of the 100 per cent excess of sulphuric acid, the reclaiming of the caustic soda and the marketing of the sodium sulphite in a useful and valuable form. The maximum yield which has been claimed for the process is about 80 per cent.

Our work has shown that the fusion operation alone will not yield more than 90 to 92 per cent of the theoretical, and in practice it is difficult to maintain this high standard. Under present conditions, the average American practice probably results in a total overall yield of between 60 and 75 per cent. As chemical processes go, the process requires an inordinate amount of labor and the repeated handling of the material gives ample opportunities for mechanical losses, particularly in view of the restlessness of workmen under present conditions.

Two methods have been suggested to reduce or conserve the excess of sulphuric acid used. Daniel Tyrer of England (U. S. Patent No. 1210725) passes benzol vapor through sulphuric acid of as low concentration as 90 per cent H_2SO_4 , at temperatures varying between 100° and 185° C. That part of the benzol vapor not reacted upon carries with it to a condenser the water of reaction, and so gives a constant concentration to the sulphuric acid, keeping it active. Tyrer claims in this way to get about 80 per cent of the amount of sulphonic acid theoretically obtainable from the sulphuric used. This method has not yet been tried on a large scale in this country.

The second method is that of Dennis and Bull, the practical application of which has been worked out by The Barrett Company. Some two years ago, Professor L. M. Dennis* at Cornell University discovered that although the solubility of pure sulphonic acid in benzol was negligible, benzol would take up from the mixture of sulphuric and sulphonic acids between two per cent and three per cent of its own volume of the sulphonic acid. In working out this idea, it occurred to Mr. Hans Bull† of that Company that the sulphonation could be made simultaneously with the extraction. These ideas have been utilized in the evolution of an extremely simple process which not only saves 90 per cent of the excess sulphuric acid as a spent acid containing 70 to 77 per cent H_2SO_4 , but eliminates a good percentage of labor, all the lime, and substantially reduces the deplorable cost of repairs, due to the many moving parts of the old installation.

The process will be easily understood from this drawing. The vessels 1, 2, 3, and 4, so-called "Extractors," each contains at rest a layer of a solution of sulphonic and sulphuric acids of vary-

* "U. S. Patents Nos. 1212612, 1211923, 1227894, 1228414 and 1229593."

† "U. S. Patents, Nos. 1247499, 1260852 and 208632."

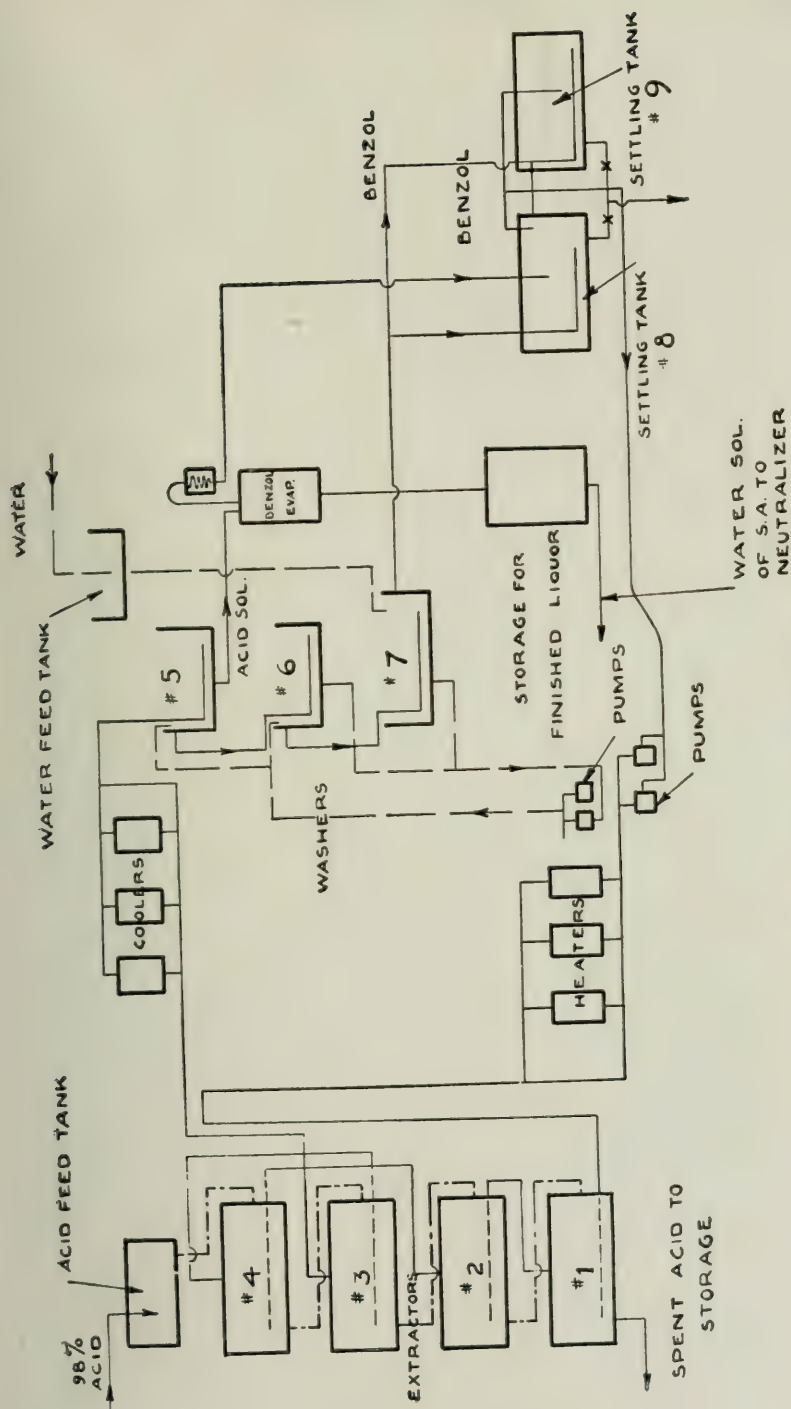


Fig. 2.—Flow Sheet, Dennis-Ball Process.

ing proportions. The benzol passes continually upward through this series of extractors, the vessels being under a pressure equivalent to the head of benzol. The distribution of the liquid in fine bubbles is effected by means of perforated branch pipes. After the passage of the benzol for a certain length of time, the solution in No. 1 is free from sulphonic acid and consists of 77 per cent H_2SO_4 . When this has been accomplished the so-called "spent acid" is withdrawn. The solution in No. 2, which probably contains 10 per cent of sulphonic acid is dropped into No. 1. The solution in No. 3, which contains probably 25 per cent sulphonic acid is dropped into No. 2, and the solution in No. 4, which contains probably 40 per cent sulphonic acid is dropped into No. 3. Into No. 4 is then slowly introduced a charge of 98 per cent sulphuric acid. The flow of benzol is not interrupted at any time. Sulphonation takes place almost immediately and the volume of the benzol flowing through, approximately 200 gallons per minute, is so great as to effect almost instantaneous removal of the heat of reaction. The benzol is maintained throughout at a temperature of 60°C . This is accomplished by heaters at the bottom of the system and coolers at the top. After passing through the coolers, the benzol, which will contain approximately two per cent sulphonic acid, passes successively through the washers, 5, 6, and 7, containing water. The benzol falls from one vessel to another by gravity, there being no pressure on this part of the system. The sulphonic acid remains in the water and the benzol leaves the last washer entirely relieved of its burden. It is passed to large settling tanks where the rate of flow is slowed down to such an extent as to allow the sulphonic acid solution, carried in suspension, to settle and from these tanks, flows to the pump and is forced through the heaters to the extracting system once more. When such an amount of sulphonic acid has been deposited in Washer No. 5 as to bring it to the strength desired, it is removed to an evaporator and the solution from Wash No. 6 pumped to No. 5, and that from No. 7 to No. 6. Fresh water is put into No. 7. A water solution of sulphonic acid can be obtained containing 60 per cent or even more sulphonic acid and contains also about two volumes per cent of benzol in solution. The benzol is removed by evaporating a small percentage of the water. The solution of sulphonic acid is then neutralized, either by the carbonate solution from the phenol blowers or with the solid sulphite of soda. The sodium

benzene sulphonate obtained contains some five or six per cent of sodium sulphate, due to the solubility of sulphuric acid in the

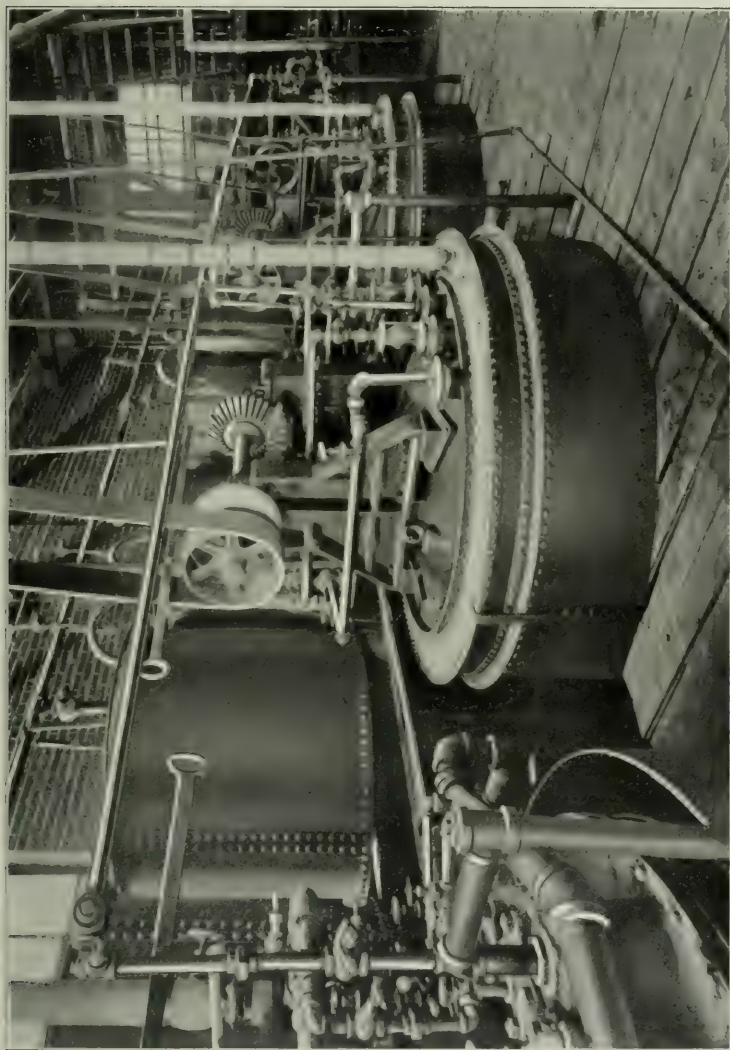


Fig. 3.—Sulphonators, top view.

benzol solution of sulphonic acid (one part sulphuric to twenty parts sulphonic). The advantages of the process are obvious. The initial cost of the plant is about 50 per cent of the old style plant,

which it displaces, it runs practically without attention and requires from one-third to one-fourth the number of laborers. Taking for granted complete extraction of the sulphonic acid, which proves quite possible, and a removal of the benzol from the water solution of sulphonic acid, the losses possible are confined to mechanical causes, that is, either leaks or evaporation. The yield under the old process, from benzol to sodium benzo sulphonate, is

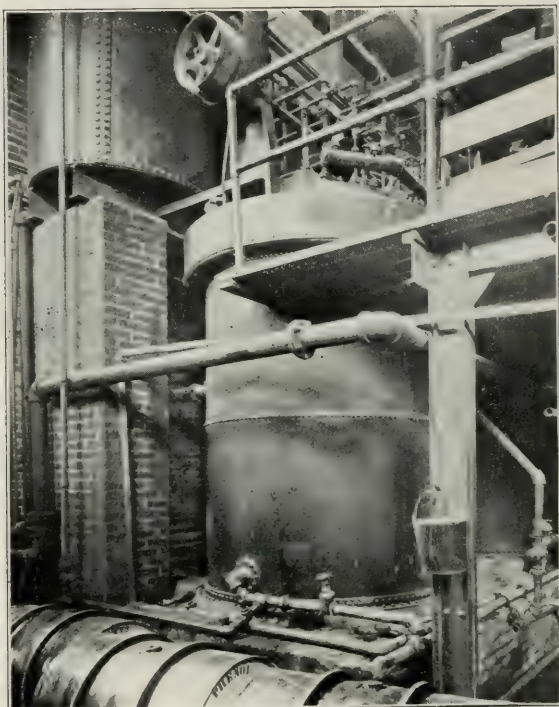


Fig. 4.—Sulphonators, side view.

about 90 per cent. The new process makes easily possible a yield of 98 per cent, leaving the mechanical losses out of consideration. The formation of disulphonic acid and of sulphone is negligible. The operations (1) discontinuous sulphonation, (2) liming, (3) filtering, and (4) evaporating, involving complex machinery and many moving parts, have all been displaced with the one simple and continuous operation, extraction and sulphonation going on simultaneously, the only moving parts being two small pumps.

The enormous simplification of the process achieved will be made more evident by photographs than by any description (see Figs. 3 to 16).

The spent acid is concentrated to 93 per cent and used repeatedly.

Another improvement in the process very generally adopted, has been the so-called "Liquid Fusion," by means of which the drum dryer with its dust and spatter, has been eliminated. Liquid fusion consists in the introduction of a saturated solution of sodium benzene sulphonate directly into liquid caustic soda at a point above

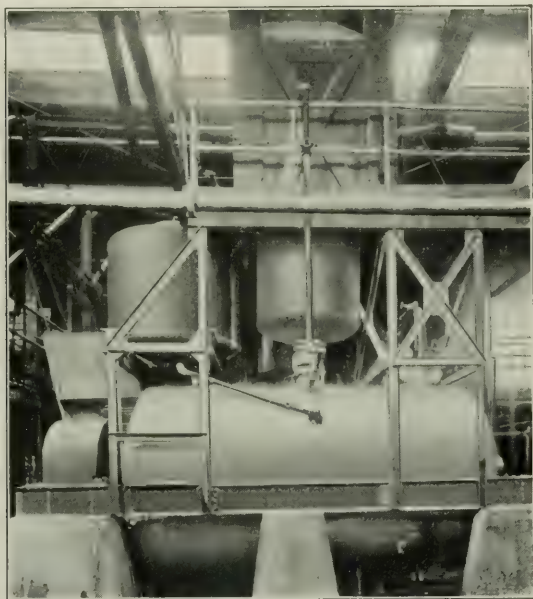


Fig. 5.—Agitators.

the reaction temperature. The reaction, when the temperature is properly controlled, goes even more smoothly than with the solid, since there is no tendency to dust and float, and the rapid evolution of the steam gives better agitation. The fusion is a great source of loss in yield. Well conducted fusions where the temperature has been kept down and which for that reason show no evidence of oxidation, give between 86 and 90 per cent yield. Our experience shows that using the liquid fusion method, a high yield is more easily obtained than with the dry salt.

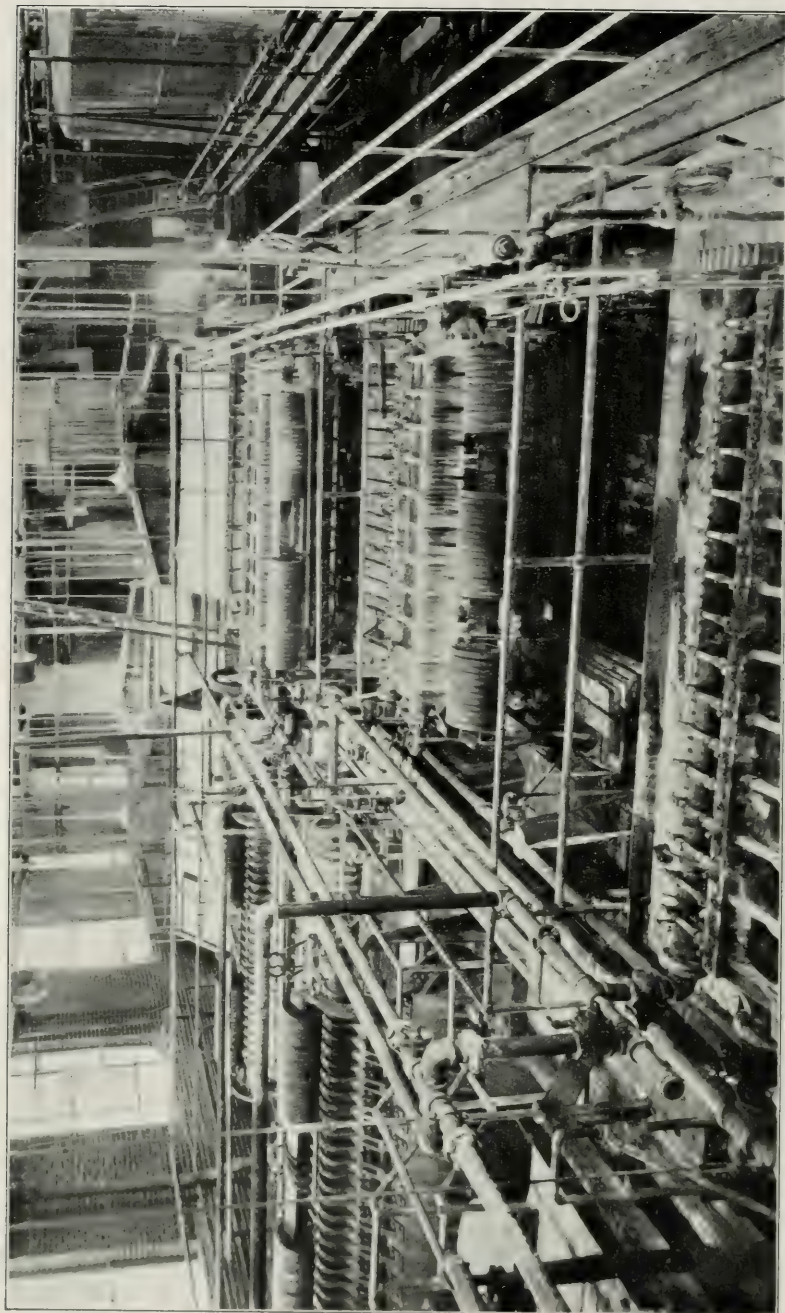


Fig. 6.—Filter Presses.

So much for innovation. Another important economy to be achieved in this process, and one even more important than that of sulphuric acid is of caustic soda. Neutralizing the phenolate with sulphuric acid, as is often done, is a gross and inexcusable waste. Providing that the lime can be utilized the difference in



Fig. 7.—Evaporators—Dissolvers.

cost between the neutralization with CO_2 , as generated from limestone and with sulphuric acid, is immeasurably in favor of the former and the operation is exceedingly simple, once the necessity for clear solutions is understood and the fact of the solubility of phenolate in phenol. If any salts are precipitated by the carbonation of the phenolate, an emulsion is obtained from which the phenol will settle only with great difficulty. The avoidance of this

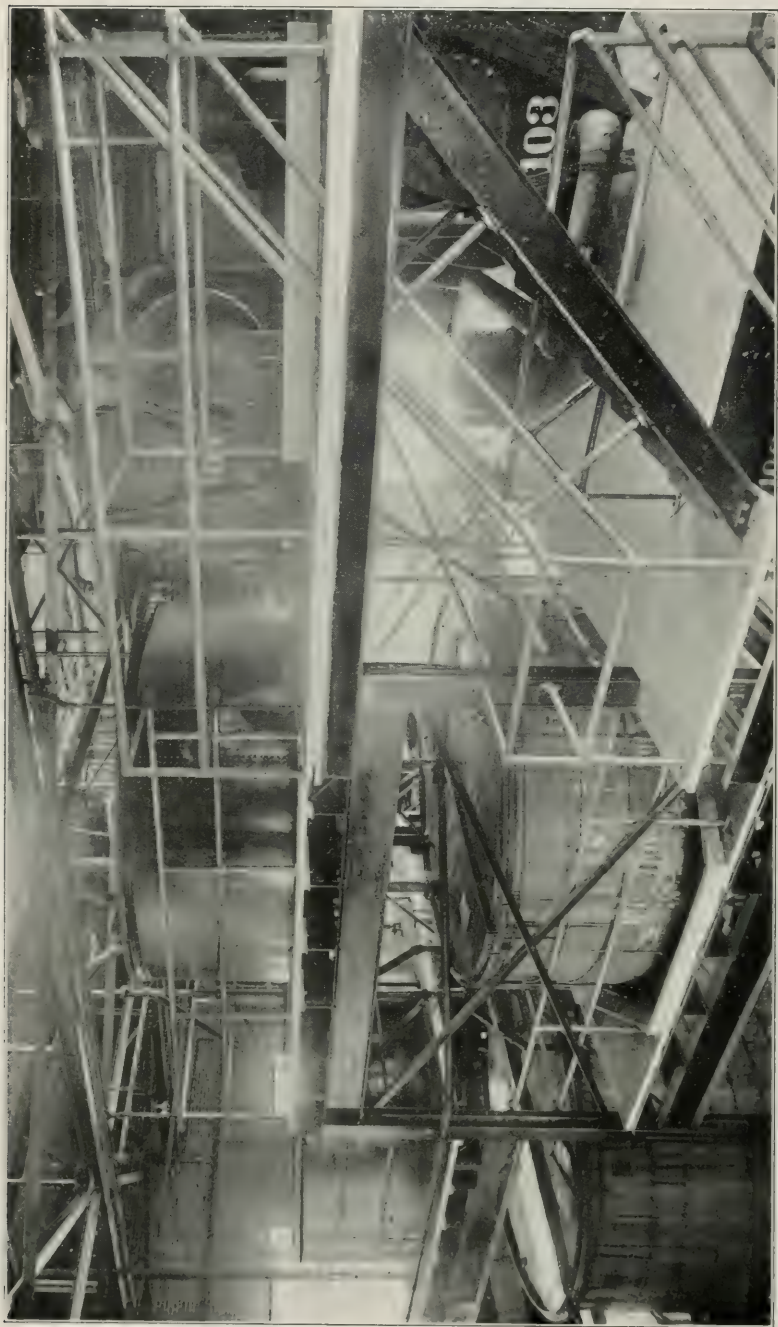


Fig. 9.—General Arrangement S. A.

emulsifying is merely a question of dilution, however, and no real obstacle is involved. The soda, not only of the phenolate, but the

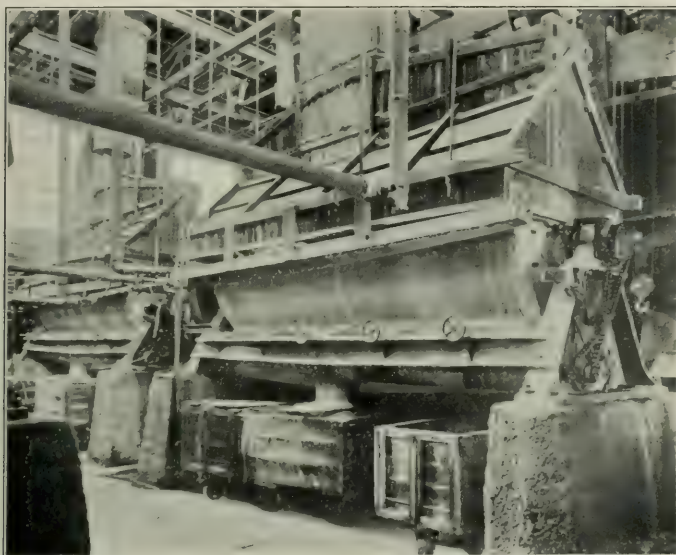


Fig. 8.—Drum Dryers.



Fig. 10.—Extractor.

excess soda, is gotten in the form of a weak solution of sodium carbonate, which can be readily causticized and made available at the plant for the fusion operation.

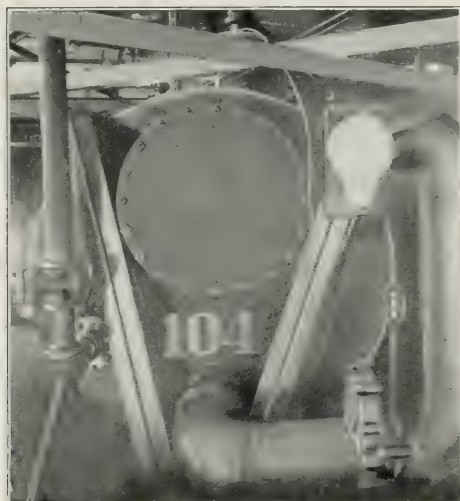


Fig. 11.—Recording Gauge, Automatic Temp. Control.

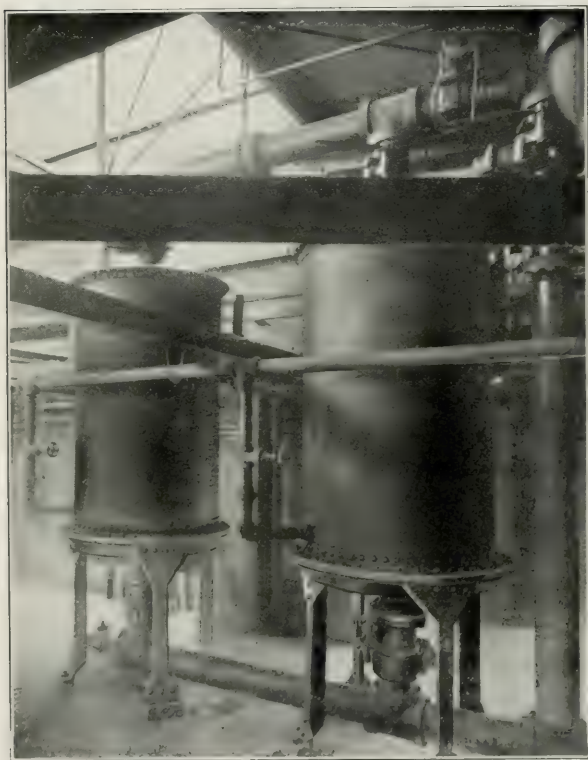


Fig. 12.—Coolers.

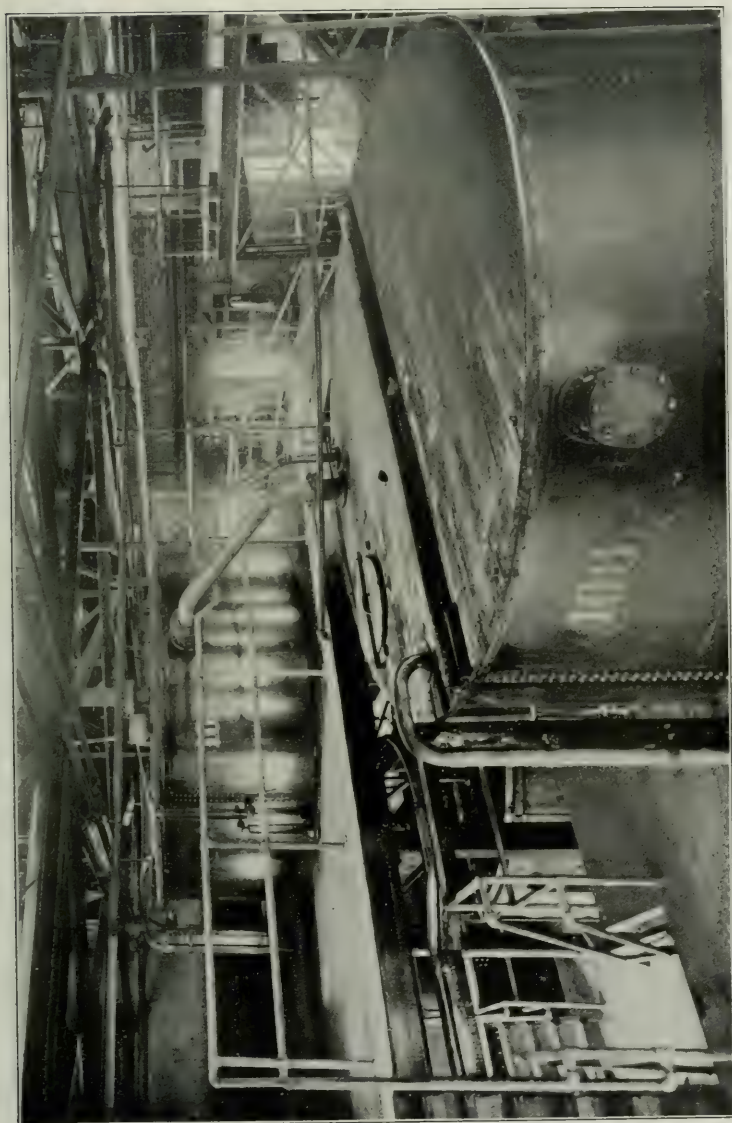


Fig. 13.—Washers.

The fusion reaction is:

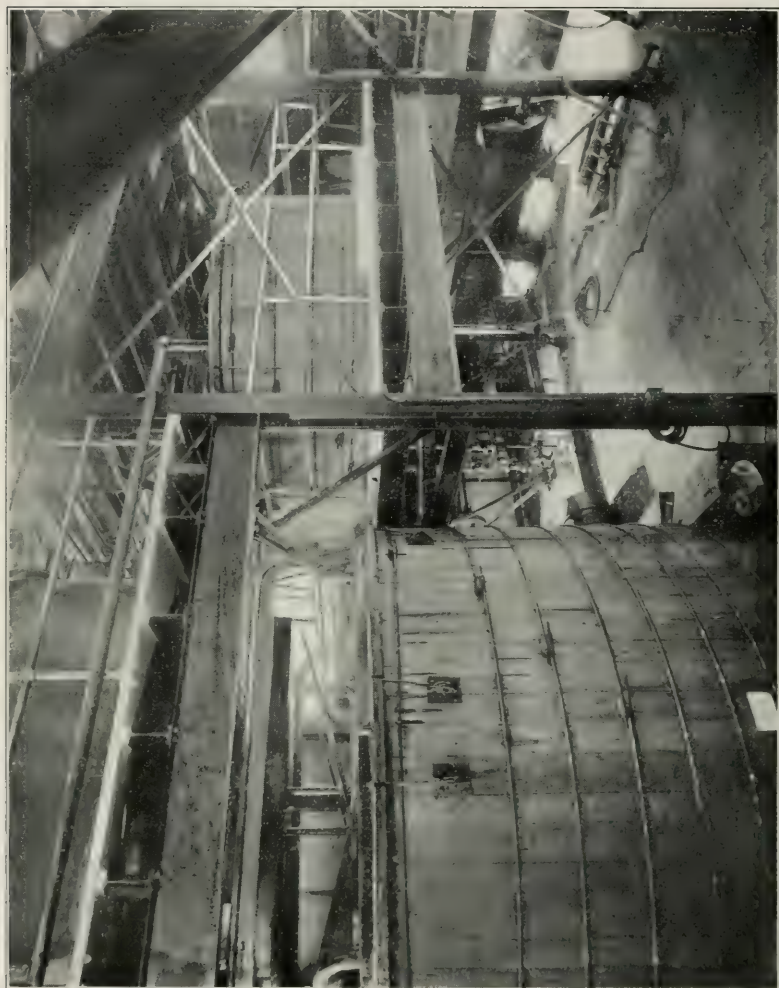


Fig. 14.—Final Wash Tank and Receiver for S. A. Solution.

If half of the sulphite is used for the formation of the soda salt, only one molecule of soda is consumed and this goes out of the plant in the form of sodium sulphite, a useful and marketable product. Since in the Dennis-Bull process, SO_2 is evolved from

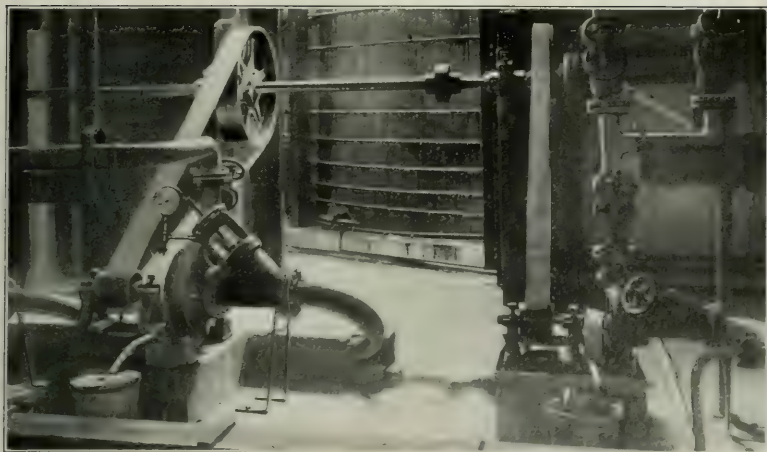


Fig. 15.—Pump and only working parts.

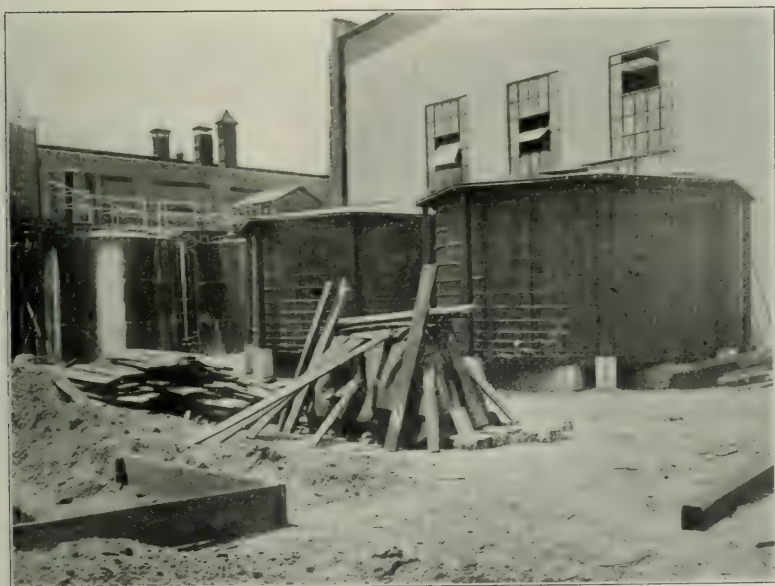


Fig. 16.—Settling Tanks.

the neutralization of the sulphonic acid, when sulphite is used it is possible also to produce bisulphite of soda.

The large amount of limestone needed is not a relatively important objection from the point of view of cost, but it presents a transportation problem of considerable magnitude. The disposition of the calcium carbonate sludge from the caustization may involve considerable expense. From the transportation point of view alone the calcination of the carbonate sludges, in rotary kilns, as a source of CO_2 , and of lime, is justified. This has been successfully tried in connection with other operations and has been found economical in districts somewhat remote from the limestone fields.

If the various economies indicated were taken advantage of there would result a startling decrease of raw materials:

Of Sulphuric Acid.....	40%
Of Caustic Soda.....	60%
Of Lime	90%
Of Limestone	100%

and a corresponding decrease of tonnage to be transported from a total of 884,000,000 to 397,214,400, per million pounds of Phenol, or about 50 per cent.

DISCUSSION

The VICE-PRESIDENT: The last two papers are now before you, gentlemen, for discussion.

Mr. CHUTE: I would like to ask Mr. Weiss if he feels that our enemies are in possession of the information he has given us on the manufacture of synthetic phenol.

Mr. WEISS: In view of the fact that it was in actual use considerably before the United States went into the war and the thing was public, I suppose the Germans had about as much information as to these as to other patents.

Mr. CHUTE: Then this is an American invention; but it was invented before the beginning of hostilities.

Mr. WEISS: Yes.

The VICE-PRESIDENT: In regard to Mr. Russell's paper, I remember at the time the price of gas in New York was reduced by the legislature from \$1.00 a thousand cubic feet to 80c. per thousand cubic feet, the gas company was very much alarmed over the procedure; and a prominent gas chemist in New York told his employers: "You don't need to be frightened at this reduction.

For the last twenty years you have been playing politics and making the laws, and now," he said, "you can just make gas"; and when you figure the importance of the by-products obtainable from the gas industry as outlined by Mr. Russell, it seems certain that the next few years will see a development along these lines which will make the by-product industry from the gas industry as important as it is to-day in the glucose and meat industries.

Is there only a little phenol produced from coal tar?

Mr. WEISS: A comparatively small amount.

The VICE-PRESIDENT: Is there a large amount in Europe?

Mr. WEISS: I don't think so. The U. S. production is not as large as Europe's but you take the whole world's production of phenol from coal tar, that is, extracted directly from the tar, naturally existent in the tar—it would not be much. Pure phenol is less than half a per cent of the coal tar itself.

The VICE-PRESIDENT: Has this pink color that develops on ageing the phenol been removed?

Mr. WEISS: Not entirely. There are about as many theories of the pink color developed in phenol as there are chemists who have had anything to do with phenol; so I would not burden you with my particular theory.

Mr. BEBIE: In connection with sulphonation, it has been our experience that the percentage of SO_3 in the sulphonation acid is not limited to 10 per cent; you can get with higher percentages of SO_3 a good yield on sulphonic acid and only very small amounts of sulphones by changing somewhat the conditions of the sulphonation.

The VICE-PRESIDENT: When I was a student at Heidelberg University we used to precipitate sulphonic acids as sodium salts by saturating the solution with sodium chloride instead of precipitating with lime filtering and decomposing the lime salt with soda.

Mr. WEISS: It would not be suitable for phenol manufacture. The reasons would be that the precipitation is not complete; in the second place, you have the evolution of hydrochloric acid, which would not be very practicable from a chemical engineering standpoint; and, in the third place, your by-products (sodium sulphate) would hardly be removed with the amount of the solution separated. That has been used in other sulphonation processes where the sodium salt is quite insoluble in dilute acid solutions but does not do well in the sodium benzene sulphonate process.

Mr. GROVE: Why they don't extract the cyanide in the coke oven gas from the by-product coke ovens; or are the conditions there different from the coal and gas?

Mr. DODGE: I don't think I can answer that. I know one coke oven plant that is extracting the cyanide; I know of one or two cases where apparatus for its extraction is being installed.

Mr. GROVE: Extract cyanide in what form?

Mr. DODGE: One I have in mind is making the sodium salt—sodium ferro-cyanide; that is the Citizens Gas Company of Indianapolis, Ind. They have about 100 Otto ovens, and are building 50 Wilputte ovens. They are making the sodium salt. I have seen the plant.

Mr. GROVE: We have gotten samples from them; but I didn't know how it was made.

Mr. DODGE: Their product is very pretty.

Mr. GROVE: Yes, it is.

Mr. CHUTE: I should like to ask—Mr. Dodge is probably most familiar with this—as to whether any of the by-product plants are converting part of their ammonia to nitric acid and using that nitric acid to neutralize the other part of the ammonia, thereby producing nitrate of ammonia direct, rather than by the indirect methods that have been discussed here of making nitric acid from sodium nitrate, which, of course, necessarily involves transportation for a long ways from the fields of Chile and neutralization of ammonia by the sulphuric acid, which, in turn, has to be eliminated before we make ammonium nitrate; and it seems to me that if we could oxidize part of the ammonia and neutralize directly, that we would have a much better process of producing ammonium nitrate, which is what the government wants at the present time more than anything else.

Mr. DODGE: I would say that, so far as I know, there are none that are doing it. So far as I know, there is nobody but the government making nitric acid from ammonia in this country; and it looks to me to be entirely too large a proposition for a gas plant, or a coke oven plant.

Mr. BEBIE: There are some other reasons why it would not be practicable. Of course, the plants are equipped for dissolving ammonia with sulphuric acid, but not with nitric acid—which would require altogether different cells in the installation.

The VICE-PRESIDENT: Is there a commercial process for the

partial oxidization of the ammonia, so that you would have ammonia and nitric acid simultaneously present?

Mr. CHUTE: Perhaps that might be a good process; but this idea being that part of the ammonia gas might be oxidized to nitric acid and used to utilize the residual ammonia.

The statement has been made that Kopper's have all the best processes in utilizing gas residuals, which statements would probably be objected to by the Solvay Company, who I think at least fifteen years ago produced synthetic phenol in this country and made picric acid which was supplied to the United States government in large quantities. I might call attention to the fact that the government has lately taken some charge of the Kopper's works, having discovered that they were largely in the control of our enemies; and under the circumstances it is quite possible that all the advance towards making a military explosive that might be possible has not been developed by them owing to their Teutonic leanings.

Mr. DODGE: I would just say that the only nitric acid being made from ammonia that I know anything about, was that done under the wing of the government at the present time.

In regard to the statement that the Kopper's Company is the only company that has made advancement in the recovery of by-products from coke, I would also take exception to that statement; like many other points, I wanted to go into detail in the paper. The three largest companies building coke ovens in the United States at present are, of course, the Solvay Company, the Kopper's Company, and the Wilputte Coke Oven Corporation. The Solvay Company have undoubtedly carried the recovery further than any other single company. The Solvay Company do recover cyanides which as far as I know the Kopper's Company have not recovered so far; although they point out how it can be done.

The VICE-PRESIDENT: Is synthetic toluol becoming a market proposition yet, Mr. Dodge?

Mr. DODGE: The only synthetic toluol is that coming from the Rittman process. The Rittman process was exploited for some time; and there have been processes which have been looked upon with some favor of splitting down the higher boiling naphthas of the coal tar series into toluols; but as a matter of fact, even at the present price of toluol, I don't think they are very attractive. The

cost of operating and maintenance is higher. I think that is one of the reasons that the Aetna Company has abandoned the Rittman process. Another reason is that cracked toluols specially those made from petroleum are so high in paraffins that they do not nitrify to the proper T. N. T.; in other words, the T. N. T. does not have the proper melting point. There has been some of the higher naphthas cracked in the water-gas process, etc.; and I am told with reasonable success; but I don't believe that is going to be the output that will solve the war problem.

The SECRETARY: I think Mr. Russell has been misconstrued. His reference to the Kopper's Company treatment was that "practically all of the work which has been done on benzole and toluol in this country, has been done by the H. Kopper's Company." I think he means to say, in there, "practically all the work done on the recovery of benzole and toluol," because that is the . . . section.

Mr. DODGE: That statement is no truer than any other part of the statement.

Mr. CHUTE: I should like to ask Mr. Dodge if it is a fact that the Washington Gas Company, with, perhaps, government aid, has been extracting toluol, for more than a year, from this water-gas plant—being directly produced by the splitting up of the petroleum which is used for enrichment; and I should like to ask, further, if the toluol production of the Consolidated Gas Company of New York is not produced in their water-gas plants, the toluol being made from the splitting up of petroleum in the ordinary enriching process.

Mr. DODGE: As I said in my paper, there are about four to five million gallons being produced by the scrubbing of gas-works gas this year.

Mr. CHUTE: I want to discriminate between coal-gas and petroleum gas as producers of toluol.

Mr. DODGE: The New York City gas is part coal-gas and part water-gas; and nobody has disputed the fact that toluol is produced from enriched or carburetted water-gas. I mentioned that in my last addition to the discussion; but there are no processes which distinctly start out to make toluol by cracking petroleum that have been successful so far as I know. That is the point I want to make.

THE MULTIPLE TANGENT SYSTEM FOR THE MANUFACTURE OF SULPHURIC ACID

By L. A. THIELE

Read at the Gorham and Berlin Meeting, June 21, 1918.

The Multiple Tangent System is directed as an improvement of the Tangent System described in U. S. Patent No. 688872 issued to Dr. Theodore Meyer and has as its main object a more rapid and continuous circulation and thorough mixing of the gases from which the acid is made. In addition I aim to reduce the dead space in the bottom of the lead chamber thereby increasing the capacity of the system as a whole.

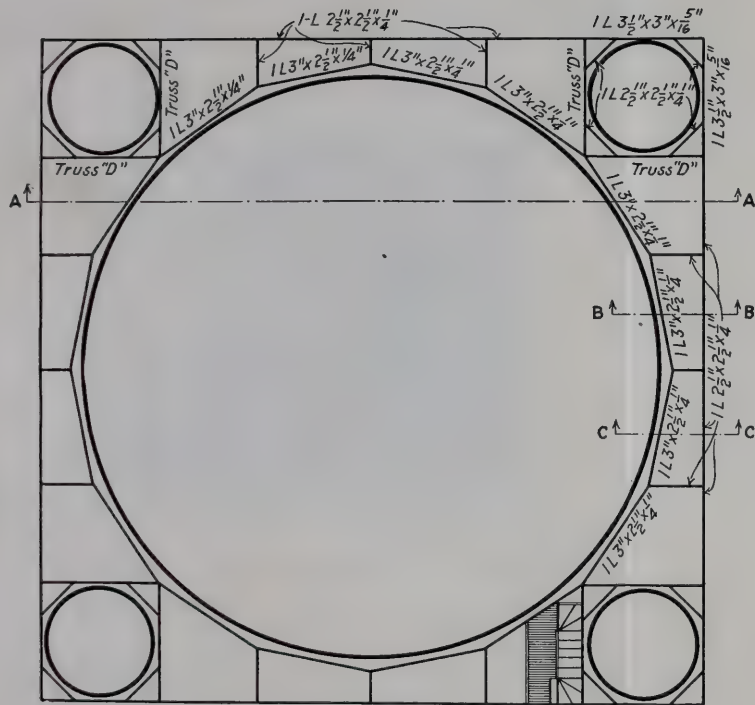
The patent to Th. Meyer referred to above, shows a series of circular or polygone shaped lead chambers in which the gases are introduced tangentially by one flue near the top of the chamber and taken out by a centrically disposed outlet in the bottom; a later patent application M. 29081, dated February, 1907, shows two inlets opposite each other one of which is arranged at a level about 15 feet lower than the first; while the outlet remained the same.

While the Tangent System which has been built in over fifty installations, has proven a success, especially in intense production, my practice with this system suggested the improvement which terminated in the Multiple Tangent System.

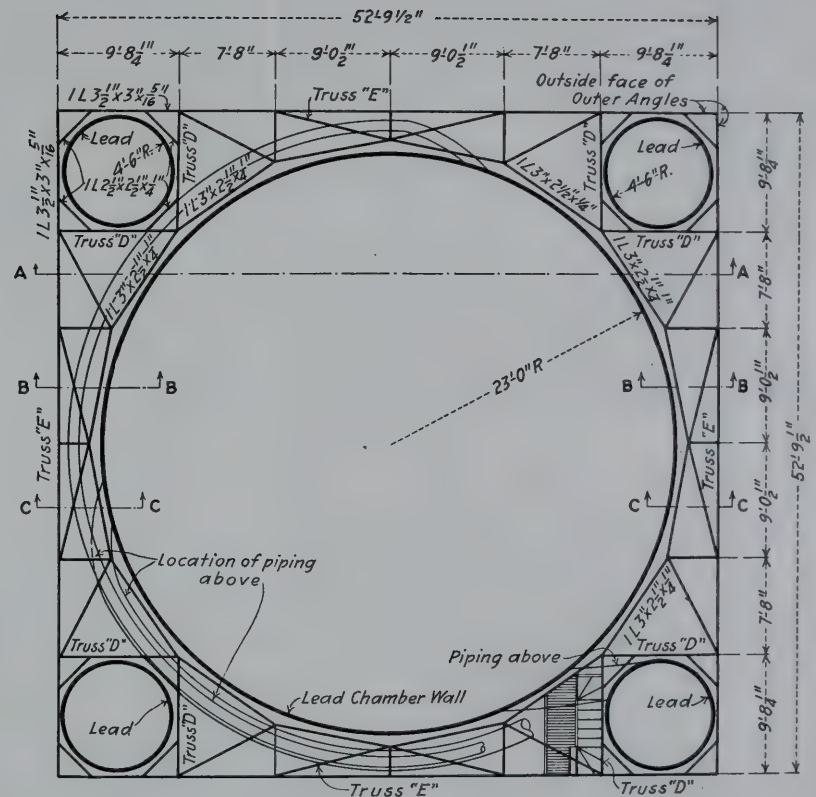
It is understood that the efficiency of a lead chamber plant depends on the degree and the rapidity with which the various gases are caused to mix in order to form sulphuric acid and to this end the Multiple Tangent System introduces the gases to the chamber or set of chambers by a plurality of conduits, the rate of flow from the various conduits being different. By this manner the gases are introduced at different temperatures by each flue and as they all enter tangentially the gases commingle more thoroughly than is possible by the Tangent System of Meyer. The novelty of the apparatus by which this is accomplished, is found in providing conduits of different lengths and areas, the smallest pipe

being of the greatest length and the largest pipe of the shortest length. The gases entering the chamber through the shortest pipe will show a higher temperature than those entering through the smallest pipe. Also, the volume in the largest pipe will be greater than the volume in the smallest pipe and, consequently, cooling of the gases in the smallest pipe is also more readily accomplished. With this arrangement it follows, that for a constant pressure supply, where the temperature of the gases flowing through the pipes is reduced, the pressure of those gases in the pipes must be correspondingly reduced, since the volume cannot be changed, the pressure varying directly with the volume and inversely with the temperature. Then, by loss of heat through radiation the gases enter the lead chamber under different pressures, which of necessity must cause a more thorough mixing than where they all enter uniformly.

After this introductory explanation I shall now describe in more detail the principles underlying the Multiple Tangent System. The gases from any sort of burner, after having passed a dust chamber enter the Glover tower and leave at the top of this tower by a series of flues of different sectional area, entering the chamber as near as possible to the top in such a manner that the smallest size flue is carried for the greatest length around the chamber, while the largest flue enters the chamber direct. Take, for instance, a system with three tangentially arranged flues, their point of entrance is found by transcribing the diameter upon the periphery; numbering them consecutively 1, 2 and 3, the sectional area of flue 1 is the largest, 2 is reduced and 3 still more reduced. In the first construction the different sectional areas were designed at the rate of 1, 2, 3. The gases after entering the chamber describe a rapid spiral motion whirling continuously around the top trying to gain their equilibrium; as well as moving along the chamber curtain by inertia; the new and continuously following supply gradually dislodges the gases toward the interior of the chamber and forces them to execute a spiral motion downward. Cooling slowly the moving gas cylinder approaches in spirals the outlets in the chamber, which are arranged in the bottom of the same. Where a single centrally disposed outlet is provided, the gases, in their escape must naturally follow somewhat the shape of a funnel, thus leaving the lower portion of the chamber as a dead space. In the Multiple Tangent System are provided a plurality of out-



PLAN BELOW ANY TRUSS "E"
Except Lowest Truss



PLAN ABOVE ANY TRUSS "E"

FIG. 3.

To face page 172

lets, in the present instance three, arranged on a circle concentric with the reaction chamber and whose diameter is approximately half that of the chamber proper. Looking down from the top of the chamber the outlets are interposed between the inlets.

From the chamber the gases enter a cooling tower or spray catcher near its top tangentially, are withdrawn from the side near the bottom and go from there to the final Gay-Lussacs in the usual manner. Fig. 1 illustrates a small size model of the apparatus.

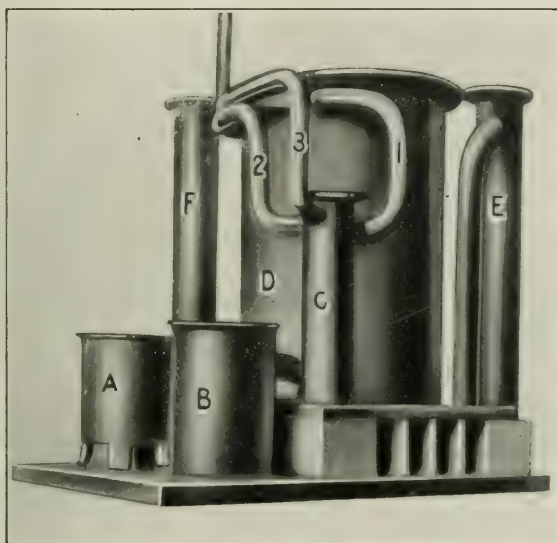


FIG. 1.—Model of Plant (constructed in 1/60 of actual size).

- A—Is a furnace.
- B—Dust chamber.
- C—Glover tower.
- D—Chamber.
- E—Cooling tower or spray catcher.
- F—Gay-Lussac tower.
- 1, 2 and 3—Tangent flues.

Besides increasing the capacity of the plant as a whole the Multiple Tangent System also saves floorspace, requires less lead in its construction and is remarkable for the ease with which it starts.

The first plant to be constructed after the Multiple Tangent Process is the 30-ton plant built for the Fairmont Chemical Company at Fairmont, West Virginia, of which the following is a description, illustrated by Figs. 2 and 3. This plant is also very interesting for the reason that it uses as source of Sulphur the coalbrasses of the Fairmont region—a by-product of coal mining. These coalbrasses contain as high as 15 to 20 per cent of coal and are used just hand cleaned. The CO_2 carried along with the gases did not cause any drawback whatever. The Fair-



FIG. 4.—Foundation of the chamber.

mont Chemical Company operates now under Government contract and details of its operation will be given in a later paper. This paper, in its scope will deal exclusively with the principle of the Multiple Tangent System and its data of construction.

Figure 2 shows the general arrangement of the tangent flues, their connection between each other and the outlets from the chamber.

The Fairmont System required a total floor space of 4900 square feet; of which 2788 square feet are for the chamber plant and 2112 square feet were used for the furnace plant.

The chamber building proper is square 52 feet 9 inches by 52 feet 9 inches; furnace building 52 feet 9 inches by 40 feet. The system consists of one Glover tower 9 feet in diameter by 42 feet high; chamber 46 feet in diameter by 69 feet high, all other towers 9 feet in diameter by 68 feet high. Cubical capacity of chamber is

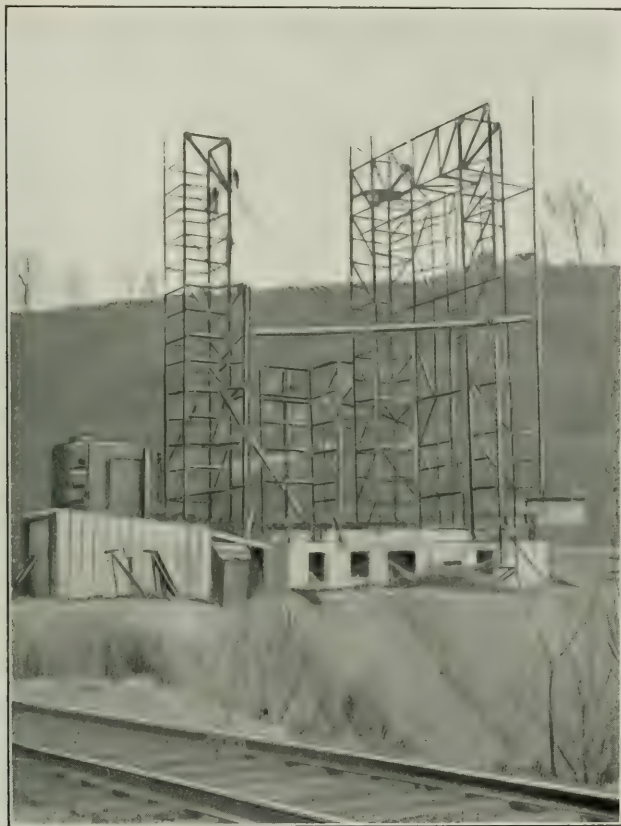


FIG. 5.—Erection of the steel framework.

113,000 cubic feet, Glover tower equals $2\frac{1}{4}$ per cent of the chamber space; cooling tower 3.8 per cent and the two Gay-Lussacs together have 7.6 per cent of the chamber space proper (see Fig. 3).

The chamber is placed in the center of the building, flanked at each corner by one tower. Besides utilizing the space in the building in the very best manner, this form of construction stiffens

the whole structure. The plant is constructed fireproof, entirely of reinforced concrete, steel framing, and roof and sides covered by corrugated asbestos protected metal.

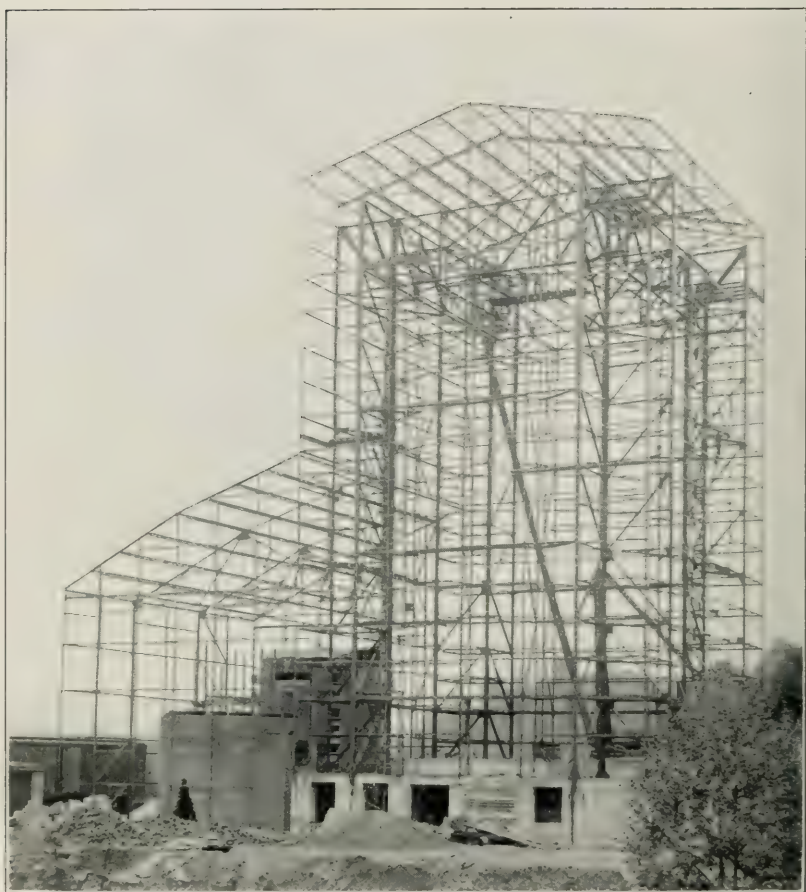


FIG. 6.—Steel framework after completion. Furnace and partly completed dustchamber in the foreground on the left.

Fig. 4 shows the location with concrete foundation under construction.

Fig. 5 shows concrete foundation and part of the steel framing.

Fig. 6 shows the entire steel framing, foundations, furnace and part of the dust chamber.

Fig. 7 gives a view of the Wedge mechanical roadster (20 feet in diameter) in the course of erection.

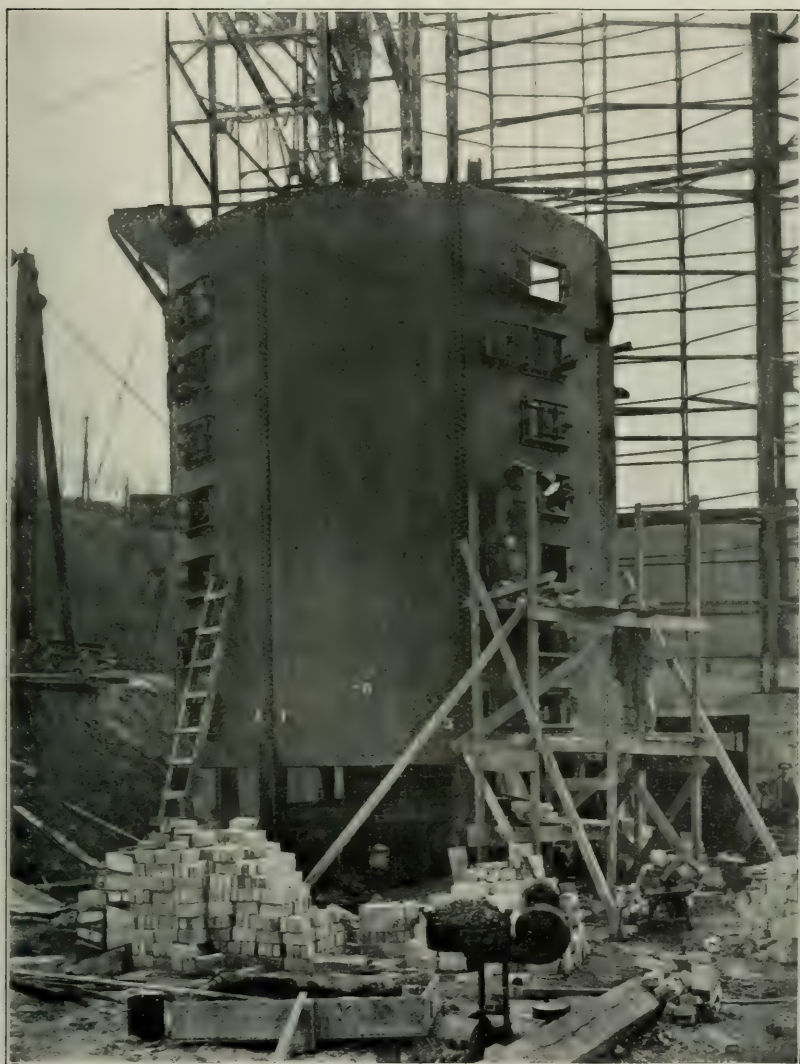


FIG. 7.—Wedge mechanical Roaster in the course of erection.

Fig. 8 illustrates the manner of erecting the towers and the hanging of the lead for the same.

Figs. 9 and 10 show the simultaneous construction of the roof and sides of the building while the erection of the towers goes on.

Figs. 11 and 12 show the furnace house and chamber building partially enclosed with one section of the Gray-Lussac tower being hoisted up.

Figs. 13 and 14 show a view of the plant with the tangent

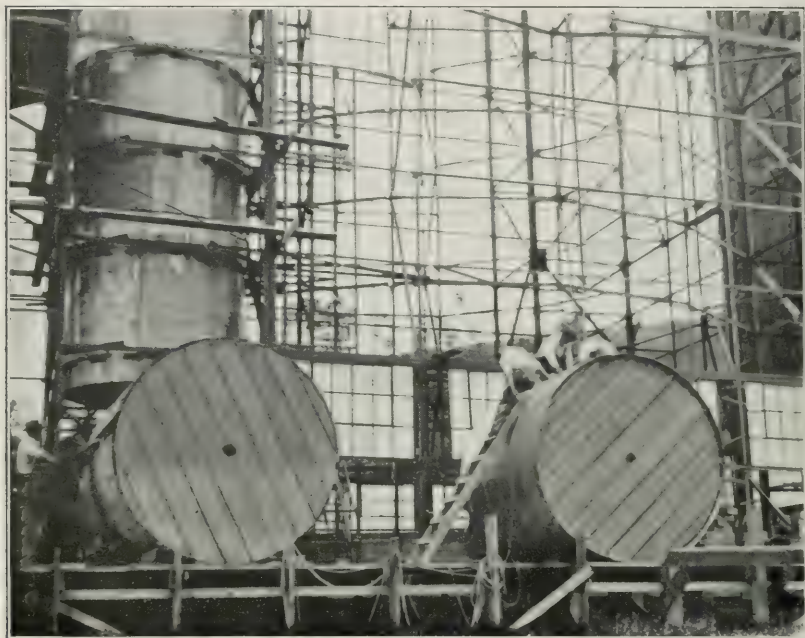


FIG. 8.—Manner of burning lead for tower sections. Glover tower on the left.

chamber completed to the last sheet of lead, the Glover and the cooling tower.

Figs. 15 and 16 illustrate the manner of strapping the chamber roof and shows the tangential flues of different sectional area running along the periphery of the chamber.

Lead Construction. Glover tower. Pan of 30-pound lead, lower part of tower of 16-pound lead, upper part of 14-pound lead; the tower is set out in checker-work pattern with hollow tile and is very loosely packed in order to allow a great concentrating action.

Chamber. Plan of 10-pound lead, curtain of 6-pound lead, top of 7-pound lead. The chamber having a capacity of 113,000 cubic feet required a total of 47.2 short tons of lead.

Cooling tower entirely built of 6-pound lead, pan of 10-pound.

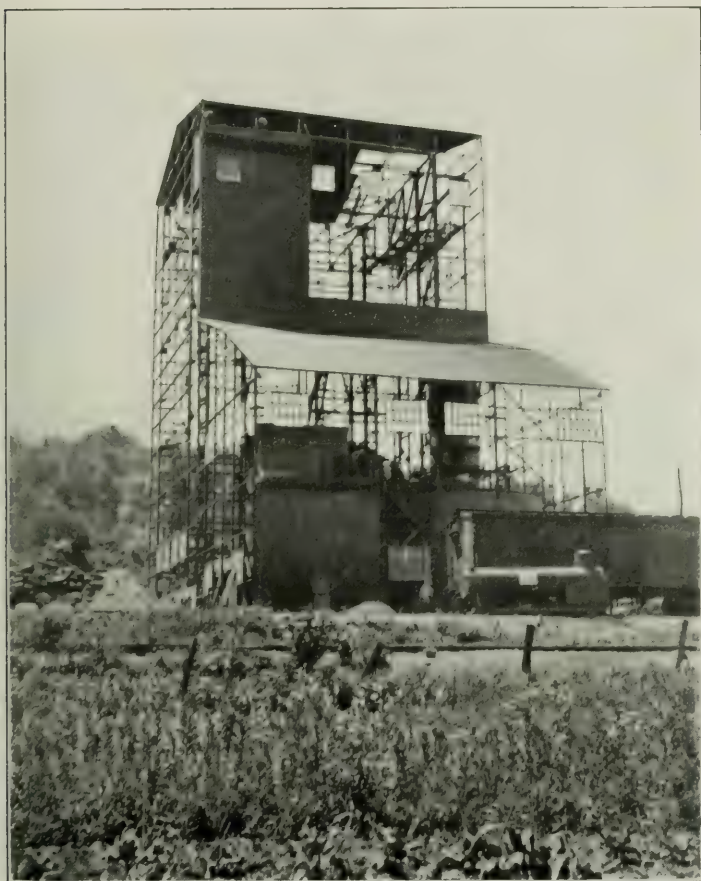


FIG. 9.—Putting on asbestos-protected metal roof and sides. Glover tower on the right.

Gay-Lussacs. Pan of 16-pound lead, curtain and top of 14 and 12-pound lead. All flues made of 10-pound lead. Including the lining of 16 tanks, coolers from the Glover acid and pipe lines, for acid distributors, seals and sprays the entire plant required 132 tons of lead.

The plant is equipped with watersprays, automatic acid eggs, blower and exhaustor, electrically driven and lighted.

An auxiliary nitric acid plant supplies the necessary nitric acid which is introduced in the system through the top of the Glover tower.

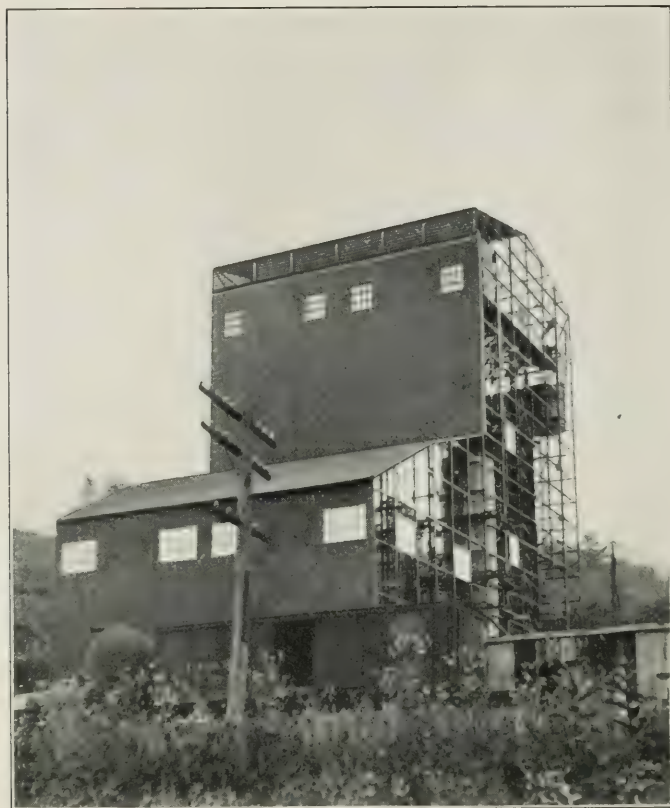


FIG. 10.—Front siding and roof completed. First section of cooling tower being hoisted up (on extreme right).

The total steel required in the erection of the plant amount to 105 tons.

As mentioned above, details relative to the operation of the plant, especially as to the burning of sulphur balls or coalbrasses will be made the object of a future paper, but I will not close this paper without attaching herewith two temperature charts, of

which Fig. 17 shows the starting of the plant and Fig. 18 the two days following the commencement of operations, which charts will amply illustrate the ease with which the Multiple Tangent System started on its way.



FIG. 11.—Building partly enclosed. Glover tower on left, cooler on right. First section of Gay-Lussac tower being hoisted up (center).

DISCUSSION

A. E. MARSHALL: Dr. Thiele's paper is of considerable interest to those who manufacture sulphuric acid by the chamber system; but until the later paper, promised by Dr. Thiele, dealing

with the operating results is published it is of course impossible to arrive at any conclusion regarding the merits of the multiple tangent system as compared to rectangular chambers having their greatest length disposed horizontally or vertically, and arranged either as large single chambers or smaller multiple chambers.



FIG. 12.—Showing FIG. 11 from the opposite side.

Unfortunately, Dr. Thiele does not state the basis of the 30-ton output expected from 113,000 cubic feet of chamber space; but if the basis is the usual one of 50° acid then the space is of the order of 9.22 cubic feet per pound of S. per 24 hours, which

is a figure obtainable as a yearly average by any analytically controlled chamber set of ordinary rectangular construction not equipped with intermediate circulating or cooling towers.

The temperature charts appended to Dr. Thiele's paper are interesting, but again unfortunately there is no reference to the point in the system where the readings were taken, so that it is impossible to judge the results. Ordinarily a variation of 25° F.



FIG. 13.—Chamber completed to the last sheet of lead. Glover tower on left, cooling tower on right. Furnace house enclosed.

such as is shown by Chart 14, at any point subsequent to the area of maximum reaction, that is to say a point in the last third of the chamber would mean either irregularity in the supply of nitric acid to the Glover tower or an excess supply of SO_2 passing unchanged through the cooling tower to the Gay-Lussac towers, with of course consequent inhibition of "niter" absorption power in the Gay-Lussac.

I would expect, and on this point I look forward with great interest to Dr. Thiele's next paper, that difficulties would be ex-

perienced in the regulation of the nitric acid feed over the Glover tower. The quantity to be used is small, unless diluted very greatly with chamber acid, and it has been my experience on small sets that the operators in endeavoring to correct a slight deficiency in

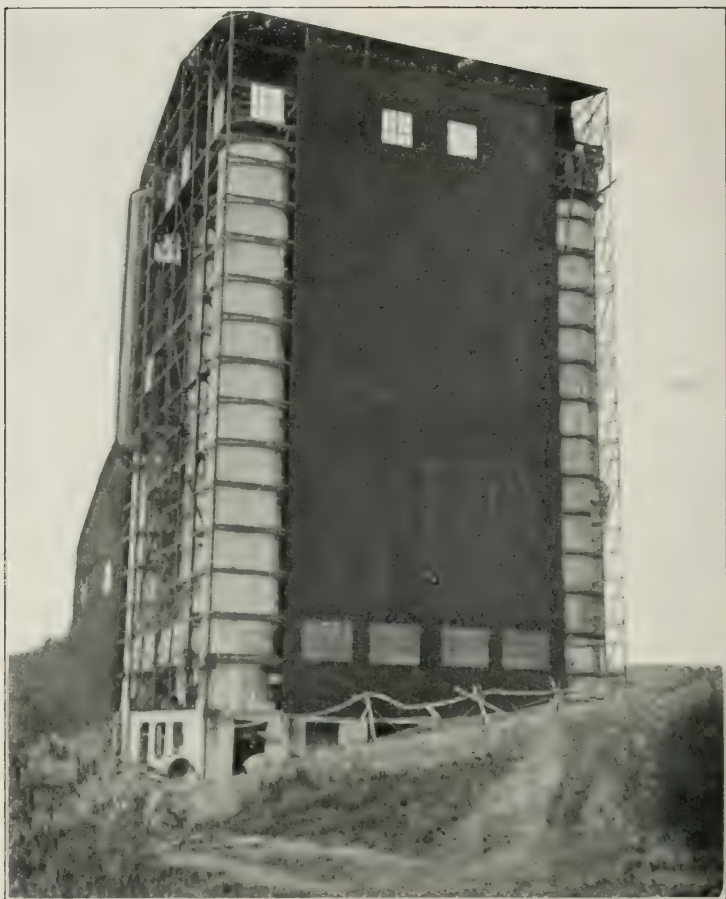


FIG. 14.—Rear view. Cooling tower on left. Gay-Lussac tower on right. Glover tower with flue in the distance on the left.

“niter” either as indicated by the sights or tests, will turn on too great a stream and then when the escape from the Gay-Lussac becomes noticeable, they will cut back too far and will thus keep the

plant continually out of balance. Such difficulties are of course not so pronounced with large sets, but even for large sets I am not entirely convinced of the desirability (from the cost standpoint) of the liquid nitric acid system.

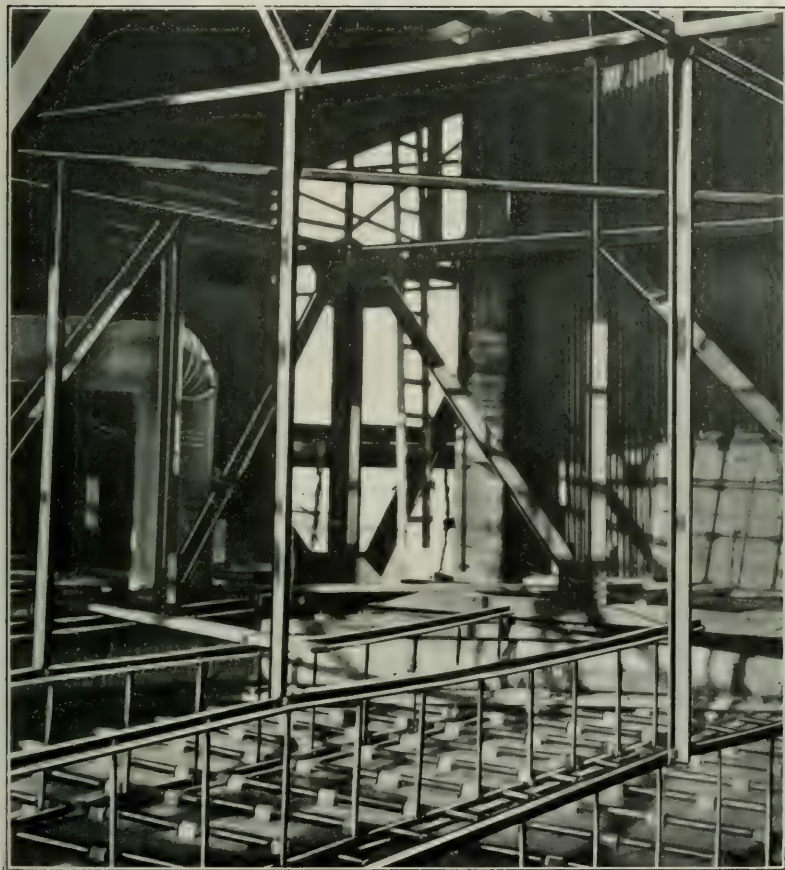


FIG. 15.—Illustrates strapping of chamber roof.

In making liquid nitric acid as an adjunct to the chamber process there is a direct loss from the theoretical yield, then there is the added cost of coal, the rapid depreciation of the nitric acid plant, and handling charges not present with certain methods of

using nitrate of soda direct. There is no saving of labor even compared to "potting" systems, as the still men of the nitric acid plant are the pot men of the "potting" set.

I believe in many plants where liquid nitric acid has been adopted, a careful survey of costs over a period of several months would show the desirability of changing over to some more direct

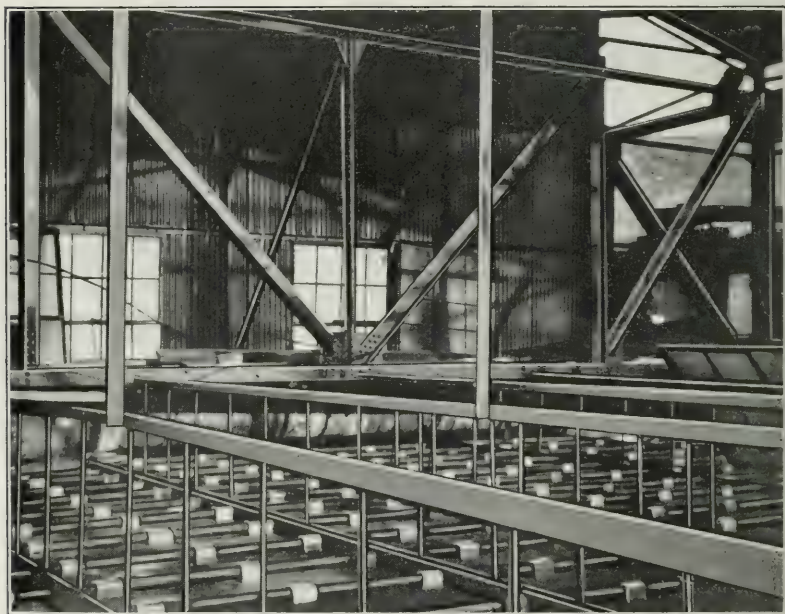


FIG. 16.—Strapping of chamber roof, tangential flues in the distance.

system where the intermediate operation of making nitric acid does not find a place.

Dr. THIELE: In answer to Mr. Marshall's discussion, I wish to say, that this plant is constructed upon the basis of 7.5 cubic feet of chamber space per pound of S. per 24 hours. The plant is expected to produce 36 tons of 50° acid per 24 hours, when running on Rio Tinto Pyrites. But as the plant is using *coalbrasses exclusively*, carrying minimal 15% of coal, the plant is expected to produce under this condition only 30 tons of 50° acid per 24 hours, owing to the large amount of inert gases.

While the system has started very nicely, we expect to experience difficulties, and especially as to precipitation of dust. As long as ore containing 15% coal is used a larger consumption of "nitre" is anticipated.

I agree with Mr. Marshall that there is no great saving of labor

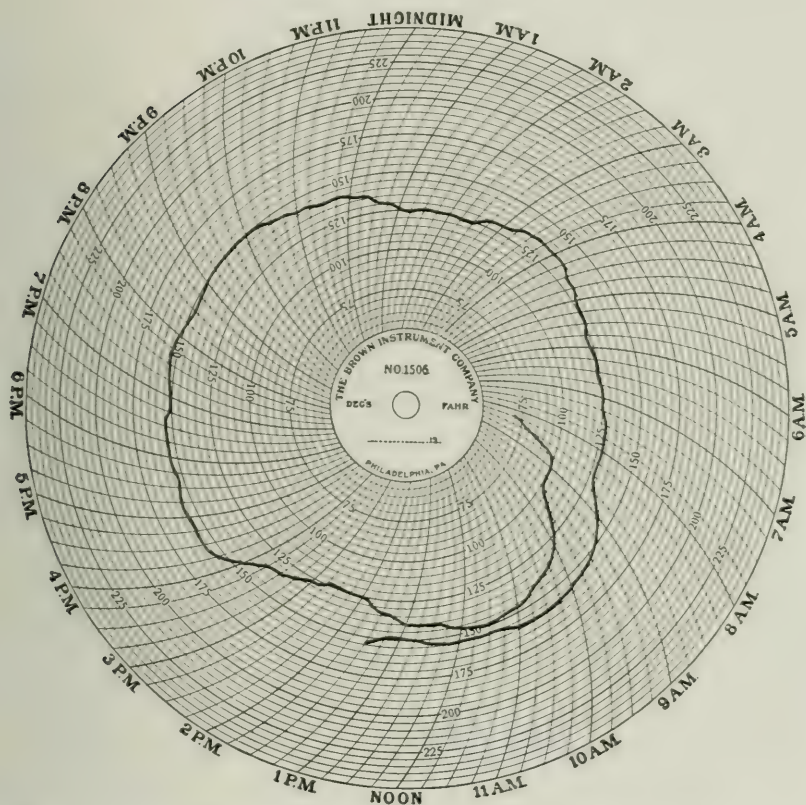


FIG. 17.—Temperature chart on starting the chamber. (Temperature taken 8 feet from top of chamber between 2 tangential inlets.)

in making nitric acid in comparison to "potting"; the advantage of using liquid nitric acid lies rather in the fact to quickly correct errors and restore normal conditions, which cannot as rapidly be done with "potting systems." This may be also the chief reason that practically every Sulphuric acid plant using "pots" has a few

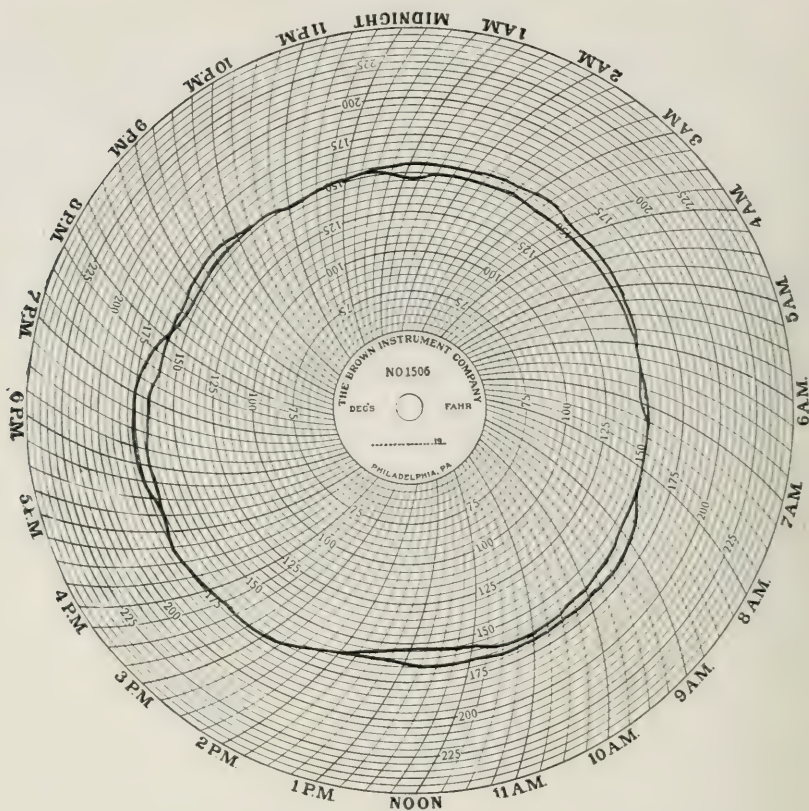


FIG. 18.—Temperature chart run for two days after starting. (Temperature taken on same spot as that of FIG. 17.)

carboys of nitric acid on top of the Glover tower "handy" for quick use.

FUSED SILICA; ITS PROPERTIES AND A FEW OF ITS USES

By STEPHEN L. TYLER

Read at the Gorham and Berlin Meeting, June 22, 1918

In looking over the literature relating to the fusion of quartz or silica for technical purposes, it is rather surprising to find that this attracted the attention of scientists as much as 90 years ago.

It was early in 1839 that Gandin submitted to the Paris Academy of Science very thin flexible threads about one meter in length which had been prepared by melting rock crystal in the oxyhydrogen flame. These results were treated simply as a matter of interest and very little was done with them until at the World's Exposition in Paris in 1878, Gautier exhibited tubes, small thermometers and similar articles made up from fused quartz. Working with Moissan he had also attempted to melt quartz in the electric furnace but was unsuccessful.

In the early nineties there was considerable activity among investigators toward the obtaining of fused quartz either in commercial or practical sizes. Among the investigators working at this time who deserve mention are—Boys, DuFour, LeChatelier and Villard. While these men did not achieve practical results they obtained valuable data on the physical properties of the vitreous quartz.

At the beginning of the 20th century English and German investigators succeeded in making important advances in the manufacture and manipulation of fused quartz. Hereaus was really the pioneer in this industrial development. He succeeded in manufacturing quartz apparatus by drilling, pressing and the working up in the oxyhydrogen flame, transparent blocks or bricks obtained by loading iridium pots with rock crystal and heating them in a large oxyhydrogen flame. The iridium pots were found to be extremely expensive due to excessive ware caused by the adhering of the fused quartz to the pots. These were ultimately replaced by melting pots made from zirconium ores.

At about the same time that Hereaus was working out the methods described, Shenstone was experimenting in England with the hand manipulation of quartz in the oxyhydrogen flame. By Shenstone's method the rock crystal was rendered brittle by alternate heating and chilling and this brittle mass broken up into small grains. The next step in this process was to soften innumerable of these grains so that they would adhere to each other and thus a crude rod was formed. This rod was subsequently worked in the flame and drawn until a thread was obtained which was then wound around a platinum rod. This hollow cylinder was heated further while still on the platinum rod and practically a complete fusion of the entire wall was obtained. Upon the removal of the platinum rod a very satisfactory quartz tube was obtained. Manufacturing tubing in this way, of course, was a very slow operation. It is said that six hours' labor might be required to form a tube 1 mm. in diameter and 45 cm. long. Working entirely in this way, the product, of course, would be prohibitive in price for any but special applications where some particular property of the fused quartz made it indispensable.

The statement is attributed to Hereaus that "quartz glass will always be expensive and the glass industry need fear no competition from this direction." This statement, of course, was true as long as the oxyhydrogen flame was used as a source of heat. With the oxyhydrogen blow pipe, it was estimated that the cost of manufacture very closely approached \$100.00 per pound and that only small laboratory articles were possible.

In 1904 a process was perfected by which quartz could be fused and subsequently shaped so as to produce a great variety of articles and in sizes much larger than had previously been possible. This process was the result of experimental work carried on by Bottomley & Paget in England.

This new process developed by Bottomley & Paget was based upon the use of the resistance type of electric furnace. A fine grade of glass makers' sand was the raw material. The electric furnace as a source of heat of course proved much cheaper than the oxyhydrogen blowpipe and the quartz sand was also much more readily obtainable than the very fine grade of rock crystal required by the other processes. By the Bottomley & Paget process the melt obtained was relatively a very large mass of plastic fused quartz which was in the form of hollow cylinder of a sufficient degree of

plasticity to remain coherent and allow of it being removed from the furnace immediately and moulded in the open without reheating.

Experiments have been made with various forms of arc and resistance furnaces but the latter type is much more satisfactory for working silica. Carbon and graphite have been successfully used as the resistance material. Extreme care must be taken in the operating of furnaces using carbon or graphite as the resistance material, from the fact that the proper working temperature for fused silica is but a very few degrees below the formation temperature for carborundum.

Fused silica starts to soften at a temperature of about 1500° and slowly becomes more plastic as the temperature is increased but at about 1750° begins to volatilize without ever going through an intermediate liquid state.

The electric furnace process was soon seen to be a practical one but the problem of obtaining the proper refractory material with which to line the furnaces presented itself. This lining material must be one which is readily obtainable and which would not exhibit basic properties at the temperatures encountered. It was found upon investigation that none of the usual refractories would be satisfactory for this work and the problem was finally solved by using the silica sand, from which the melt was to be obtained.

The temperature of the mass to be worked was approximately 2100° C. and of course was cooling very rapidly so that all manipulation of this must be done with extreme rapidity. The fall in temperature of this mass has been estimated at from 50 to 70° per second.

The melt thus obtained was in the form of a hollow cylinder which could be moulded into such shapes as pipe, retorts, crucibles, basins, trays, etc.

Fused quartz has properties which are entirely characteristic of this one material. Probably most important among these is its extremely low coefficient of expansion.

Table showing coefficients of expansion of fused quartz:

Temp. Range.	Expansion Coefficient.
$-80^{\circ}-0^{\circ}$ C.	$.22 \times 10^{-6}$
$0^{\circ}-30^{\circ}$	$.42 \times 10^{-6}$
$0^{\circ}-100^{\circ}$	$.50 \times 10^{-6}$
$0^{\circ}-1000^{\circ}$	$.54 \times 10^{-6}$

To more clearly bring out the extremely low coefficient of expansion it should be noted that for the crystalline quartz parallel to the axis the value is 7.5×10^{-6} and perpendicular to the axis 13.7×10^{-6} . For Royal Berlin Porcelain the value is 2.8×10^{-6} ; while for Jena glass No. 59 is 5.7×10^{-6} .

Uses for fused quartz readily suggest themselves from this one property of extremely low coefficient of expansion. Among these I will only mention the application in thermostat construction where a quartz rod or tube may be used as a non-expanding element. In connection with this work it might be said that a rod 1 meter in length would expand five-tenths of one millimeter when heated to 1000°C .

The specific gravity of fused quartz when obtained from rock crystal is 2.2 and the fused quartz obtained from sand is 2.07. This difference in specific gravity is probably due to the fact that the fused quartz obtained from sand always carries a multitude of small air bubbles. The fused quartz obtained from the rock crystal when manipulated in the oxyhydrogen flame would be the transparent grade which is practically free from air bubbles due to the fact that it is worked in small quantities and the masses are thin so that the air bubbles have sufficient opportunity to come to the surface thus leaving only the solid mass whereas with the grade obtained from sand which is usually much more opaque, the melt obtained is of such size that the air will not force itself out of the melt even at the temperature obtained when the material reaches greatest plasticity.

In some of the Cottrell precipitator insulations where high temperatures are encountered and high voltage currents are to be insulated, fused silica cylinders have been used to act as supporting members and also as insulators. In order to ascertain what might be a safe load to be imposed upon these cylinders some tests were made at the engineering laboratory of Columbia University and some very surprising results were obtained. Cylinders of the following sizes were tested:

3.85" internal diameter 4.95 o. d. 24" in length
and

4.15" internal diameter 4.75 o. d. 24" in length

These cylinders were set up in Tinius Olsen tensile strength machine and compressive load applied slowly. The results obtained

would indicate that cylinders of this size might be subject to a dead load of about 20,000 lbs. per square inch of end surface area.

With cylinders 6.1" i. d. and 7.3" o. d. 24" long

6.25" i. d. and 7.5" o. d. 24" long

very similar results were obtained but slightly lower making an average safe load for cylinders in this size about 14,000 lbs. per square inch.

With cylinders 7.8" i. d. 8.9" o. d., 24" long

7.5" i. d. 8.85" o. d., 24" long

an average dead load of about 15,000 lbs. per square inch could be considered as safe load. A further test was made with a cylinder 9.55" i. d., 10.7" o. d., and with this the complete failure of the cylinder occurred when load of 18,650 lbs. per square inch had been applied. From these results it would indicate that at ordinary temperatures fused silica cylinders of from 4" i. d. to 10" i. d. could be safely loaded to about 7 tons per square inch, providing of course that this load was a dead load. No attempts were made to determine what the safe load might be at elevated temperatures as the results obtained indicated that the safety factor was extremely high for any probable installations.

All fused quartz when exposed to high temperatures shows a tendency to revert back from the vitreous to the crystalline state. Devitrification of fused silica has been the subject of a large number of investigations by different observers and as the matter is of considerable importance, I will read a summary of an investigation by the National Physical Laboratory of England:

"In general, the loss of strength hardly commenced at 1120° C.; at 1188 C. it existed, but was not very serious, even after eight hours heating; but four hours heating' at 1350° C. produced a reduction of 40 to 50% in strength, showing that the rate of loss of strength increases very rapidly as the temperature rises."

From this it will be seen that although for continuous operations fused silica cannot be exposed to temperatures over 1200° C. yet where exposures are only for short periods of time the material may be used successfully at much higher temperatures. An example of this class of work might be the reading of temperatures to about

1300° C. with a noble metal thermocouple using the fused silica tubes as insulating and protecting tubes.

Fused silica has been found to be absolutely insoluble in distilled water which makes it extremely valuable for such work as the preparation of pure distilled water to be used in the making up of solutions for subcutaneous injections as distilled water prepared by the usual method frequently carries traces of the heavy metals or alkalies which impurities have been noticed to have direct biological and physiological effects. Fused silica apparatus composed of still and condensing line has been very satisfactorily used for the preparation of pure distilled water to be used in connection with delicate conductivity work where the presence of the small amounts of alkalies absorbed either from the condenser or from the storage vessels would seriously effect results.

Fused silica is insoluble in practically all acids either organic or inorganic. The exceptions to this are hydrofluoric and phosphoric acid. The action of hydrofluoric acid, however, is very much slower than is the case with the crystalline material, but nevertheless the action is appreciable. Some very interesting work has been done to determine at just what strengths and temperatures fused silica equipment would be satisfactory for use with phosphoric acid solutions. The acid used was of a specific gravity of 1.75 and this was heated in an open silica crucible and maintained at a constant temperature. The surface area of the silica exposed to the acid was 20 square centimeters, the loss of weight was as follows:

After 48 hours at 270° C. the total loss of weight was but .21 gr.

After 48 hours at 217° C. the loss in weight was .038 gr.

After 144 hours at 217° C. loss of weight was .1 gr.

Assuming that the action is proportional to time it would take 1.4 months to dissolve away the thickness of 1 mm. of silica at 270° C. and 8 months to dissolve away the thickness of 1 mm. at 217° C.

As a check upon these results we might mention that fused silica in the form of dishes has been and is being used for the concentration of phosphoric acid solutions, and dishes used for this work only show very little action of the phosphoric acid upon them.

Fused silica has been found to have an extremely high electrical insulating value which coupled with resistance to high temperature changes has rendered it very valuable in certain classes of electrical work. The Bureau of Standards give the value for volume resistivity

as: over 5000×10^{15} ohms. per centimeter at ordinary temperatures. The National Physical Laboratory of London have shown that decrease in insulating value is about as follows, at 230° C. is one-tenth that at 150° C., and at 250° C. is one-eighth that at 230° C. The difficulty of moulding and shaping fused silica has prohibited its more extensive use in this field.

A few tests were made recently to determine what might be the approximate insulating value of fused silica tubing in a plant installation. For this test an insulator was made up from two pieces of tubing, one to be placed inside the other, the inner tubing being $\frac{3}{4}$ " bore and about $1\frac{1}{8}$ " o. d. and the outer tubing being $1\frac{3}{8}$ " i. d. and about $1\frac{5}{8}$ " o. d. and an extract from the report on this test is as follows:

"At 85,000 volts by ratio the current flow through the insulator is so low as to cause no deflection on millimeter reading in unit milliamperes in the high tension circuit while the low tension current equaled the exciting current of the transformer plus losses." The current in this case was rectified alternating current but very similar results have been indicated by experimental work with high frequency alternating current.

There are at the present time several grades of fused quartz on the market; the oldest form of fused quartz might be said to be the transparent grade which was the first to be obtained, this being the product obtained when the crystalline quartz is manipulated by using the oxyhydrogen blow pipe as the source of heat. With the introduction of the electric furnace process of producing fused quartz the opaque grade was first produced. Later manufactures by the electric furnace process produced a semi-transparent or translucent grade which when made up into small articles such as laboratory flasks, crucibles or dishes, often showed sufficient transparency to render easy visible through the wall the level a water white liquid. These three grades all showed the same physical properties. The slight differences being in mechanical strength and specific gravity. The National Physical Laboratory of London, England, report that they found the transparent quartz tubing considerably stronger at all temperatures than the opaque. The difference in specific gravity has already been thoroughly covered.

These three grades have always kept a more or less uniform relation to each other as regards cost. The purely transparent always being extremely expensive, the translucent grade consider-

ably cheaper and the opaque grade much cheaper than either of the other two. This latter grade has been furnished at prices which very favorably compare with the better grades of glass and chemical stoneware and is invariably used at temperatures much higher than those to which these could be subjected, this point entirely overcoming the difference in first cost.

A new process has been developed for the manufacture of transparent fused quartz which will reduce the cost of this grade considerably over what it has been previously. By this process much thicker plates can be produced and also tubes of much larger bore and heavier wall. With the advent of a cheaper transparent quartz a number of uses are to be developed which previously have never been thoroughly worked out, due to the practically prohibitive cost of the transparent quartz.

Both the transparent and the translucent grades of fused quartz have been very much limited in their application due to the restrictions in the process of manufacture which prohibited the production of large sized articles. This want for larger sizes of apparatus in fused quartz has been filled by the opaque grade and in this grade at the present time very large pieces are produced. Among these I might mention that 15" bell and spigot pipe is now a standard article and also short lengths of 18" pipe can be produced. There has been on the market for some time in this grade various sizes of retorts, the largest of which has had a capacity of 75 liters, but recently vessels have been produced having a much greater capacity. One of the largest pieces so far produced was a tank measuring 17" wide, 36" long and 15" deep, having a capacity of approximately 140 liters. It has been found that with retorts and other similar vessels that these may be safely used up to temperatures equal to the boiling point of strong sulphuric acid. The extremely large size tank mentioned was intended for use in connection with the sterilization of cereals by passing the all ready boxed cereal through an electrically charged field using the tank as the dielectric interposed between the electrodes.

One of the earliest applications of fused silica in the opaque grade was the concentration of sulphuric acid and the form of concentrator for which silica details could be readily produced was the cascade type as originally developed for the use of porcelain dishes. This plant proved to be very unsatisfactory due to the excessive breakage of the porcelain dishes. The fused silica dishes overcame

this difficulty. At the present time there are several hundred cascade plants in use using fused silica dishes.

The cascade concentrator in general may be said to be applicable only to clean acids and in some cases difficulty has been experienced due to the insolubility of iron or lead sulphate in the highly concentrated sulphuric acid. These sulphates would separate out in the lower portion of the cascade and settle to the bottom of the dishes thus causing a bumping which might become severe enough to cause breakage of the dishes or the sulphates cake in the bottom of the dishes and thus form a hard crust which would alternately expand and contract during the operation of the concentrator and cause breakage from the excessive strain exerted on the dishes.

The quality of acid produced from the silica basin cascade concentrator is extremely high: first of all due to the absolute insolubility of the fused silica in the acid no impurities can be introduced into the acid from this source. In the design of the cascade concentrators fire gases are kept entirely apart from the acid itself so that no foreign material can be introduced from this source. The product thus always being an acid of the same purity as the feed acid. In a number of cases the concentrated acid produced in the cascade concentrator using fused silica details is used in operations where the usual commercial grade of acid would not be satisfactory. The acid produced is usually water white and practically free from sediment.

As to the operation and efficiency of the cascade concentrator it might be said that in general a unit working over the range from 50° Bé. to 66° Bé. would require about 15% fuel, this being based on the weight of 66° acid produced, a unit operating over the range of 60° Bé. to 66° Bé. would require about 13½ to 14% of fuel, based upon the weight of 66° acid produced. The fuel in all cases referred to above is soft coal of about 13,000 B.t.u. per pound.

Very satisfactory installations have been made of fused silica basins to be used as an intermediate concentrator in the production of high strength sulphuric acid. The usual form of concentrator for this work and the one probably most extensively used at the present time is the lead and iron pan concentrator. The action on the last lead pan where the acid should be about 60° Bé. is excessive as the temperatures often run above the critical temperature for the use of lead, and also the action on the first iron pan which this 60° Bé. acid is fed is excessive due to the acid being sufficiently dilute

to act upon the iron. It is at this point that a short intermediate concentrator made up of fused silica basins or trays has been installed. The cost of such installations is but very little greater than the cost of a single lead pan giving the same evaporating surface and is more efficient.

Several large size installations of the fused silica basin cascade concentrator have been made. Where a large production is required the plants are usually made up of individual units each having a capacity of about 10 tons of 66° Bé. acid per 24 hours. One single installation made in this country is at the present time producing about 190 tons of 66° Bé. acid per day.

For the condensation of nitric acid the S bend type of condenser is the one most readily adaptable to the use of fused silica details. At the present time there are several hundred condensing sets satisfactorily operating in England, France and the United States. Since the outbreak of the present war in Europe, fused silica S bend condensing equipment has been the standard plant installed by the British Government and the individual explosives manufacturers in England, and is also extensively used by the French Government. Fused silica nitric acid condensing equipment shows several advantages which cannot be claimed for any other material. It is extremely light in weight and as an example of this I would say that a standard S bend measuring 4" bore by 6' 6" between centers used in the condenser portion of a nitric acid plant, weighs approximately 25 pounds. From this it will readily be seen that the erection costs for this type of apparatus would be especially low and that the time of erection would be reduced to the minimum from the fact that pieces might be easily handled without the use of any mechanical devices for lifting. As previously stated fused silica is unaffected by the nitric acid at any strength or temperature and from this fact is almost unlimited in life. In many instances details have been used for several years and no appreciable effect can be seen with this period of constant use.

Due to the property of fused silica of withstanding sudden and extreme temperature changes, the condensers are directly water cooled which of course makes for efficiency in condensing and also reducing the size of plant required quite appreciably.

In the manufacture of hydrochloric acid by the decomposition of salt by sulphuric acid, fused silica pipe lines have been very successfully used for taking the gas away from either the pan or

roaster. From this line smaller bore lines are taken off which are directly water cooled, and the gas carried over from these through a main line to set of towers where the absorption of the gas is carried on.

In the design of apparatus made up from fused quartz special care must be exercised that there are no joints made with other materials such as glass, stoneware or metal pipe lines in such a manner that the expansion of these will cause strains to be exerted on the silica which would bring about breakage. Also in the setting up of pipe lines, the cements to be used in packing the bell joints should be carefully selected with the idea in mind that cements which set up hard will cause difficulty. So whenever it is possible cements should be used which will remain plastic throughout the period over which they are to be used. For this reason it is not practical to make up apparatus incorporating ground joints between fused silica and other ceramics or metals where temperatures are to be appreciably above room temperature and joints made up by grinding glass into the silica are unsatisfactory, but, however, joints made up by grinding the silica into glass have proved much more satisfactory.

Another problem has received considerable attention this being the sealing in of lead wires into quartz tubes. For this several types of joints have been developed which give very good satisfaction. One of these is made up by using small sections of glasses of graded compositions and so selected that the final glass used will have practically the same coefficient of expansion as that of the wire to be used. This type of joint is extremely difficult to make and furthermore is entirely covered by patents and I believe would not be readily available to the public. Another type of joint has been developed, the patents of which are controlled by one of the manufacturers of fused silica apparatus and arrangements can readily be made to utilize this process. This gas tight seal is made up by means of a running into the specially shaped end of a silica tube molten lead or similar plastic metal or alloy into which the lead wire may be securely fastened. Seals made in this way have been fitted into a variety of apparatus and have as far as I know been satisfactory. For work at low temperatures seals may readily be made by using sealing wax. Where pressures are about equal to atmospheric pressure the usual mercury seal would prove satisfactory.

Much activity has been shown of late in the development of extremely high grade spark plugs for use in aviation motors. Here conditions are such that the life of the ordinary porcelain insulators is very short and it has seemed a logical step from porcelain to fused silica for this work.

It is reported in this country that some of the aviators now in France are paying as high as \$25.00 for each spark plug in order that they may get reliable plugs. From this it would appear that there is a market for an extremely high grade spark plug and that cost of manufacture need deter no one from investigating this. Mr. W. D. Peasley in an article appearing in the proceedings of the American Institute of Electrical Engineers last year, states that "the porcelain insulator as commercially available to-day is not a success. It is deteriorating too rapidly both in and out of use and the gathered evidence points to certain features of manufacture and composition that are responsible in a large part for this unreasonable deterioration." He further states "that insulators should be made from an amorphous substance containing only one constituent or only those of the same electrical and thermal characteristics, and indicates that fused quartz is practically the ideal insulating material. ". . . " the dielectric strength of fused quartz is very high and its mechanical strength and elasticity are all that could be asked for."

One very interesting application of fused quartz is in the gas lighting field where it has been successfully used to replace glass for globes. This system of lighting has been developed to a great extent abroad, where so long as glass globes were used serious troubles in maintenance seemed unavoidable due to high operating temperature. On account of the necessity of marketing these gas lighting outfits at a moderate price it is not practical to employ globes of clear transparent quartz so the translucent grade has been used. This globe absorbs a certain amount of light but this is offset by the design of the globe in that in all cases it is designed to fit the mantle much more closely than the glass globe which of course increases the mantle temperature considerably, thus increasing its luminosity and it has been found that the temperature of the mantle can be increased to such an extent that the loss of light is not only compensated for but that there is a substantial increase in the light.

I think that this brief paper will serve as a résumé of the present

status of fused silica or quartz and may suggest some further applications or lines of development.

DISCUSSION

Mr. MOORE: Mr. Chairman, I would like to ask how these tests in regard to corrosions by phosphoric acid at given temperatures were made?

Mr. TYLER: The phosphoric acid was put in the crucible and the temperature of the crucible maintained by a gas flame.

Mr. MOORE: There then was no great flow of heat through the walls of the fused quartz crucible but simply heat enough maintained to keep the phosphoric acid at the temperatures maintained.

Mr. TYLER: That was all.

Mr. MOORE: It seems to me that the data given are of very little practical value as the method of testing did not bring out the conditions which one would encounter in industrial plants.

In 1910 I was interested in making large quantities of ethylene from alcohol and phosphoric acid; in brief, the method of making this is as follows:

Phosphoric acid is heated up and kept between 230 and 240° C. in a fused silica balloon flask containing about 50 liters while a small stream of alcohol is poured thereon. We have first a formation of ethyl phosphoric acid and water, water is given off and then ethyl phosphoric acid breaks down into ethylene and phosphoric acid. This action, however, is continuous. Under such conditions there is a large inflow of heat through the walls of the silica flasks. Under these conditions it will be seen that inasmuch as silica is a poor conductor that the walls have to be considerably hotter than the liquid itself in order that there shall be a rapid inflow of heat. I speak of this because these are the conditions which are met with in industrial practice. The walls must surely be considerably hotter than the liquid and in giving figures of corrosion it is not safe to go by the temperatures of the liquid. Under the conditions above described these fused silica balloons which are about one-quarter of an inch ($\frac{1}{4}$ ") thick would eat through in a month and so you see that the figures given by Mr. Tyler are not applicable to the practice of phosphoric acid under these conditions in actual practice where there is a large inflow of heat through the silica. I should also like to ask Mr. Tyler what action he has found on fused silica with sulphur at temperatures below 1000.

Mr. TYLER: I think there is no action at all of sulphur on fused silica.

Mr. MOORE: The same remarks which apply to phosphoric acid I think applies to sulphur. We had a problem of vaporizing sulphur in fused quartz tubes. The vaporizing point of sulphur is about 444° C. or thereabouts. In putting a large amount of heat through these quartz tubes to vaporize sulphur we found that the quartz tubes got brittle irrespective of the fact that they were far below the temperature, namely: 1200° , at which silica is supposed to stand heat. We had to give this up because fused quartz would not stand the great inflow of heat through the tube.

Mr. TYLER: I do not know of any experiments made under the conditions just stated.

Mr. MOORE: I only draw attention to the fact to show that in giving data as regards the action of chemicals and heat on fused silica that the data should be given under conditions which will meet with the industrial conditions.

STORAGE TANKS MADE OF REINFORCED CONCRETE.

By F. W. FRERICHS

Read at the Chicago Meeting, Jan. 15, 1919.

ABOUT a year ago it became necessary to construct large storage tanks for ammoniacal liquors. Usually such tanks are made of steel, but on account of the war, steel plates were not obtainable and concrete was the next best material which was available for the construction. By preliminary experiments it was proven that good concrete was not materially affected by crude ammoniacal liquor, and, in order to ascertain the permeability of concrete walls by water and aqua ammonia, four small experimental tanks were constructed and subjected to systematic tests.

The accompanying sketch illustrates the construction of the tanks, one of which was made from cement concrete consisting of one part cement, two parts sand, and four parts gravel. This tank was designated by the letter "A." The three other tanks were made from the same concrete mixture with the sole difference that in tank "B" two per cent hydrated lime was added to the cement before mixing while tanks "C" and "D" contained two per cent each of two other waterproofing materials (stearates) of the market.

Each tank carried a gauge glass on the side in which the level of the liquid in the tank could be observed. A sheet iron circular cover was cemented to the top to prevent loss by evaporation. During the test period the tanks were standing in the open air exposed to the hot summer sun and the outside surfaces appeared dry.

The inside area of each tank was 15.70 sq. ft.; the outside area was 35.74 sq. ft.

After ten days drying the tanks were subjected to the following tests with a view of ascertaining the permeability of concrete by water and ammoniacal liquor.

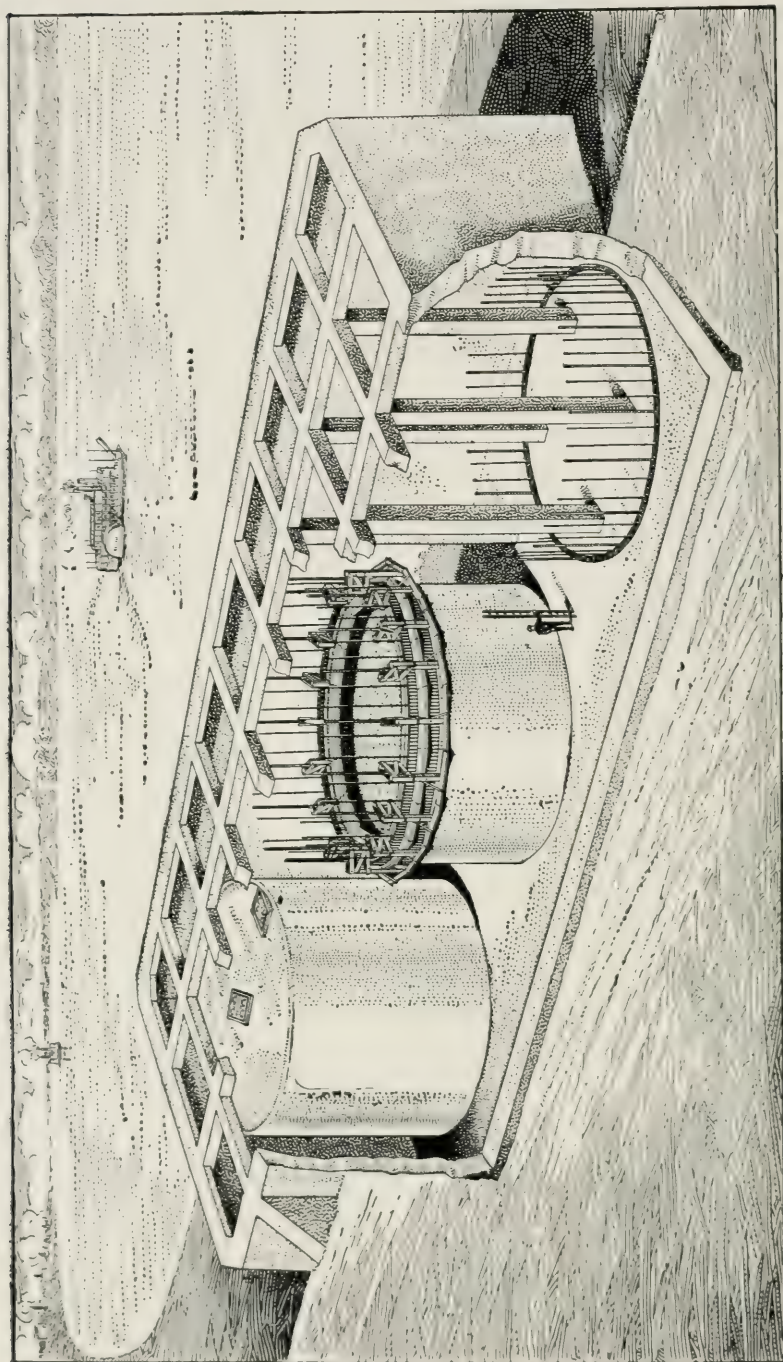


FIG. 1.—Storage Tanks of Reinforced Concrete. In course of construction.

SERIES I.—PERMEABILITY FOR WATER.

All four tanks were filled with water 18 inches high to within 6 inches from top, and the iron covers luted on tight with cement. Readings of water in gauges were taken every day at 3 P. M. and the drop in the water level was recorded as read in inches.

1917	I Temp.		II Drop in Surface.				III Evaporation.				IV Evaporation.			
	Max.	Min.	A	B	C	D	A	B	C	D	A	B	C	D
	°F.	°F.	In.	In.	In.	In.	Cu. In.	Cu. In.	Cu. In.	Cu. In.	Cu. in per Out. side	Sq. Area.	Sq. ft.	ft.
July 13	96	69	0.00	0.00	0.00	0.00								
14	81	67	0.63	0.38	0.30	0.75	285	172	59	339	11.6	6.9	2.4	13.5
15	84	67	0.75	0.38	0.19	0.94	339	172	76	425	13.5	6.9	3.0	17.0
16	83	68	1.00	0.38	0.19	1.19	452	172	76	538	18.0	6.9	3.0	21.5
17	82	64	1.19	0.50	0.38	1.38	538	226	172	624	21.5	9.0	6.9	25.0
18	83	68	1.38	0.50	0.38	1.50	624	226	172	678	25.0	9.0	6.9	27.1
19	86	69	1.56	0.56	0.38	1.63	705	253	172	737	28.0	10.1	6.9	29.5
20	90	68	1.69	0.63	0.38	1.75	764	285	172	792	30.5	11.4	6.9	31.7
21	90	69	1.81	0.69	0.44	1.88	818	311	199	850	32.7	12.4	8.0	34.0
22	93	73	1.94	0.78	0.47	2.00	877	352	212	904	35.0	14.1	8.5	36.2
23	87	67	2.06	0.88	0.50	2.13	931	397	226	963	37.2	15.9	9.0	38.5

COLUMN I. Temp. max. and min. from Weather Bureau.

“ II. Drop of level in gauge in 1/100 inches.

“ III. Evaporation in cu. inches.

“ IV. Evaporation in cu in. per sq. ft. outside area of 25 sq. ft. exposed to atmosphere.

Counting the decrease for the first day for saturation of the concrete then the average evaporation per day per sq. ft. outside area of 25 sq. ft. has been for A 2.8 cu. in.; B 1.0 cu. in.; C 0.7 cu. in.; D 2.8 cu. in.

SERIES II.—PERMEABILITY FOR 18-INCH AQUA AMMONIA.

All four tanks were filled with aqua ammonia 18 inches high to within 6 inches from top, and the iron covers luted on tight with cement. Readings of level in gauge were taken every day at 3 P. M. and the drop of level was recorded in 1/100 inches.

1917	I		II				III				IV			
	Temp.,		Drop in Surface.				Evaporation.				Evaporation.			
	Max	Min.	A	B	C	D	A	B	C	D	A	B	C	D
	°F.	°F.	In.	In.	In.	In.	Cu. In.	Cu. In.	Cu. In.	Cu. In.	Cu. in per Out side	Sq. Area	ft.	
Aug. 6	85	68	0.00	0.00	0.00	0.00								
8	85	71	0.31	0.31	0.13	0.25	140	140	59	113	5 6	5 6	2 4	4.5
9	78	64	0.56	0.44	0.25	0.38	253	199	113	172	10.1	8 0	4.5	6.9
10	76	60	0.94	0.50	0.31	0.44	425	226	140	199	17.0	9 0	5 6	8.0
11	80	63	1.25	0.56	0.38	0.50	565	253	172	226	22.6	10.1	6 9	9.0
12	79	65	1.38	0.63	0.44	0.56	624	285	199	253	25.0	11.4	8 0	10.1
13	84	66	1.50	0.69	0.50	0.61	678	312	226	276	27.1	12.5	9 0	11.0
14	83	68	1.75	0.71	0.56	0.63	791	321	253	285	31.6	12.8	10.1	11.4
15	80	69	1.81	0.73	0.63	0.67	818	330	285	303	32.7	13.2	11.4	12.1
16	86	71	1.94	0.75	0.69	0.71	877	339	312	321	35.1	13.6	12.5	12.8
17	91	72	2.06	0.81	0.75	0.75	931	366	339	339	37.2	14.6	13.7	13.7

COLUMNS I—IV designate the same as in Series I.

The aqua ammonia in the tanks did not perceptibly decrease in strength in the ten days' test. The tanks were exposed to the hot sun.

Counting the decrease of the first two days for saturation of the concrete then the average evaporation per day per sq. ft. outside area exposed to the atmosphere (25 sq. ft.) was for A 3.5 cu. in.; B 1.0 cu. in.; C 1.25 cu. in.; D 1.02 cu. in.

After these tests were made the tanks were dried out and painted on the inside with three coats of raw gas tar. The tar used for the first coat was thinned down with about ten per cent turpentine, which caused the tar to penetrate about one-eighth of an inch into the concrete. After one week's drying the tanks were



tested again with ammoniacal liquor and during several months there was no appreciable loss of their contents.

Encouraged by these results three large storage tanks were built by plans which were prepared by Messrs. Brenneke & Fay, Civil Engineers of St. Louis, who describe them as follows:

Three tanks were built in a concrete pit 47 feet 2 inches wide, 130 feet long, and 30 feet deep. The excavation for the pit was made in the slope of the river bank partly in earth and partly in solid rock. The bottom, side, and end walls rest on solid rock. The walls of the pit are designed as vertical reinforced concrete slabs, their bottom edge being heeled into a trench cut in the rock and the top edge reinforced with a flange acting as a horizontal girder. The top of the walls are tied across to the opposite walls at intervals by a system of longitudinal and transverse beams which are reinforced to act in either tension or compression, these beams being supported at their intersections by columns from the bottom of the pit. The walls of the pit are so reinforced as to resist hydrostatic pressure in either direction. The north and east walls, which are the upstream and river walls, are also designed to resist the impact of running ice during a high water stage. After the side walls were built the bottom of the pit was covered with concrete to make it tight, and is reinforced with steel in both directions as a precaution against any upward pressure that might occur during high water on account of fissures or cavities in the rock underneath. In the concrete bottom, sumps are provided to collect rain-water, seepage, or leakage from the tanks. Circular chases were also left in the concrete bottom in which to heel the side walls of the tanks in order to get a tight joint between the walls of the tanks and the bottom. The longitudinal and cross beams between the walls at the top of the pit are also designed to support a concrete floor should a building be constructed over the pit in the future. All concrete work in the pit is composed of one part Red Ring Portland cement, two parts sand, and four parts washed and screened Meramec gravel. The accompanying plans show the general design, dimensions and details, as well as the steel reinforcement of both the pit and tanks.

The three tanks are 35 feet inside diameter, and 26 feet deep. The walls are 7 inches thick, and the tops are covered with a concrete roof 6 inches thick. The manholes are provided in the roof of each tank and are constructed with a double curb of concrete

6 inches high around the openings. The manholes have metal covers in the form of an inverted pan, the edges of which rest in the groove between the curbs, and the groove is filled with water to form a seal to prevent the escape of gases from the tank.

The roofs of the tanks are also constructed with a curb about 6 inches high around the edge so that the entire roof can be covered

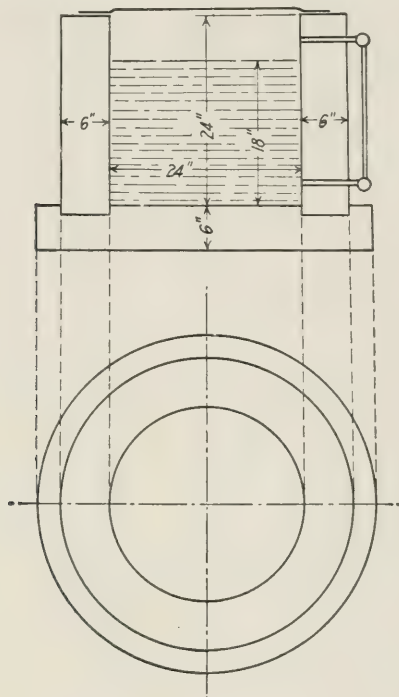


FIG. 3.

with water as an additional seal against the escape of gases through the concrete.

As the tanks are to contain ammonia liquor it is essential that they should be tight. Preliminary to their construction several small experimental tanks about 3 feet in diameter were built with and without waterproofing compounds mixed with the concrete. The plain concrete tanks apparently were watertight as those in which compounds were used. From the information obtained from these experimental tanks, and from various other sources, it was concluded that waterproof tanks could be built of plain concrete.

It is essential that all joints in the walls be eliminated and the concrete be mixed dry, that is of a consistency of a stiff mortar and then thoroughly rammed. In order to eliminate all joints it was necessary to arrange to concrete continuously day and night from the time the walls were started until they were finished. The vertical reinforcing rods were first secured in position, sixteen of which were $1\frac{1}{8}$ -inch diameter plain rods located equidistant around the circle, the balance of the rods being $\frac{3}{4}$ -inch diameter deformed rods.

On each of the $1\frac{1}{8}$ -inch vertical plain rods was placed a metal sleeve constructed with a pair of metal jaws so arranged as to grip the rod wherever the sleeve was placed. The outside of the sleeve was threaded full length and provided with a large nut. From these sleeves were suspended wooden yokes having a metal bearing on the nuts on the sleeves. To the yokes were attached the sliding forms for the tank wall and also the working platform for the men. The general construction of the yokes, forms, and platform is indicated on the accompanying perspective drawing. The forms were about 5 feet high made in sections bolted together. The faces were made of quarter-sawed tongued and grooved material laid vertically. After the horizontal reinforcing for the lower 5 feet of tank was wired in place, the forms were placed and concreting started. The concrete was delivered by a chute from the mixer at the top of the pit to the working platform and deposited into the forms in thin layers and thoroughly tamped. As soon as the concrete reached the top of the forms, the movement of the forms was started by turning up the nuts on the threaded sleeves. This work was carried on continuously day and night, no stopping in the work of concreting or movement of forms being allowed from the time of starting until the wall was finished. The placing of the longitudinal reinforcing steel was carried on at the same time. As soon as a nut reached the top of its sleeve the load on it was relieved and the nut backed down to the bottom and the sleeve slid up the rod and secured to a new position, and the process of jacking continued. The movement of the forms was made uniform by taking an equal number of turns on each nut in rotation. The rate of movement varied from about 8 inches per hour during the cool hours before sunrise to about 14 inches per hour during the heat of the day, as the time of setting of the concrete was affected by the temperature of both materials and atmosphere. After the

top of the wall was reached and the concrete set, the forms were disconnected and removed and used again on the next tank. The concrete roofs were put on at a later date after the walls were thoroughly set.

The concrete in the tank walls is composed of one part Red Ring Portland cement, two parts sand and three parts washed and screened Meramec gravel.

After the concrete work was completed and the tanks dried out; the bottom, sides, and roof on the interior were coated with three coats of tar applied with a brush as an additional precaution against leakage of liquid gas.

The tanks were then tested by filling with water. In the walls of the first tank built there was some leakage through slight lifting cracks which was due to the slow movement of the forms. These lifting cracks were avoided by more rapid movement of forms on the balance of the work. The leaks gradually healed up and have practically disappeared.

The capacity of each tank is about 185,000 gallons, and cost approximately \$10,000 exclusive of the tank pit.

CONCRETE AS A CHEMICAL ENGINEERING MATERIAL

By MAXIMILIAN TOCH

Read at the Chicago meeting, January 16, 1919

It may truly be said that this is the age of concrete. What progress would our new factories have made after this country went into the war, when steel and iron were unobtainable, had it not been for the ability to use portland cement in its place? It is no criticism to say that portland cement concrete is an unfinished material when used in the erection of chemical works. No floor in any factory will last very long made of portland cement and sand, unless it is treated in some manner. I have seen instances where the concrete foundations of vinegar tanks were decomposed until they resembled a material like cheese, owing to the solvent action of acetic acid. I have seen foundations of motors and machinery where the oil drippings disintegrated concrete in a relatively short period. I could cite many more cases, but these will suffice. There are a great many materials which preserve portland cement construction against acids, alkalies, oil and saline solutions, but there is no one material which may be regarded as a panacea for all the defects of concrete. When the defects of concrete are mentioned I must again impress upon you that I am not criticising the material; but a concrete sidewalk is about the only cement construction of any magnitude that I can recall which needs no treatment to make it waterproof, wearproof and weatherproof.

DEFECTS OF CONCRETE CONSTRUCTION

Take the case of a concrete floor in a room where there is delicate machinery. In a short time the particles of sand and broken stone which form the composite of the concrete become loosened, float around in the air and lodge on the contact points of this delicate machinery. Take the case of foundations in chemical works, where acids and alkalies drip on the foundations. Take the

case of concrete foundations of factory buildings on a waterfront, where niter cake and sludge acids are discharged in the stream, and you will soon erode the concrete foundations. All this is due to a very simple chemical reaction. Portland cement has been described so often that I do not need to go into its chemical composition other than to say that when it is mixed with water it generates lime and the lime forms a glutinant material which binds the particles together. This same condition is identical in all mortars, and the common, ordinary lime mortar of building material, while it contains a much greater amount of lime than portland cement, is weaker in every respect than portland cement itself. Lime is slightly soluble in plain water and is relatively more soluble in salt water. This accounts for the disintegration of portland cement at the seashore. Any acid, no matter how weak, forms a chemical combination with lime, and when the lime is attacked in portland cement the structure itself crumbles.

METHODS OF PRESERVATION

There are a large number of methods used for the protection and preservation of portland cement; and as I have said before, there is no single method applicable in every case. Our Government and every other Government have had an enormous amount of trouble in building dry docks which would withstand sea water, even though some of these dry docks were faced with granite or other building stones, because the building stones must be cemented together with a mortar containing lime in some form. A very interesting case developed in one of the large dry docks in New York Harbor, where the sea walls were waterproofed with an integral material but where the bottom was not waterproofed, and after a lapse of five years the solvent action of the salt water attacked the bottom, but left the sides untouched. But the greatest problem of all is the construction of foundations, vats and storage buildings for chemical materials which should be proof against acids and alkalis under normal conditions. Up to within two years ago no one ever thought of building storage warehouses of concrete for the storing of large quantities of niter cake. This material, as you know, is an acid sulphate of sodium containing as high as 30 per cent of free sulphuric acid, and yet it has been possible to build successfully such a storage building which would house niter cake and not attack the walls and floors made of concrete. In a case

like this, it is necessary to use two methods—one, an integral method, and in addition to this, a surface coating which will be acidproof.

CONCRETE TANKS FOR STORAGE OF OIL

The great scarcity of boiler plates for the building of large tanks forced our own Government to build tanks for the storage of fuel oil, of concrete; and, as there are two kinds of fuel oil—the very heavy Maltha, of the West Coast, and the thinner type of Pennsylvania and Ohio—it soon becomes obvious that the Maltha or Western type could be stored in any kind of a pit made of any material, but the Eastern oil would soon destroy the crystalline structure of portland cement and leak through. So it became essential to find methods of making concrete oilproof, and in this again the integral plus the surface coating method are essential.

To use a very homely comparison, and one that is somewhat graphic, I must frankly state that unless the engineers' specifications are strictly carried out, failure will inevitably result and no material should be blamed for a lack of supervision. To write a specification for concrete and chemical engineering construction is not an easy matter, and unless the inspector is intelligent and watchful, failure may result. I always think, in this connection, of the case of the man who went into a restaurant and called the waiter, and explained to him the kind of a steak that he wanted. He insisted that the steak should be an inch and a half thick and six or seven inches long, and it should be grilled over a coke fire for forty-five minutes at a distance of one foot from the fire; that after it was grilled it should be smothered with mushrooms and onions and then allowed to seep for ten minutes and placed on a hot plate and served to him. The waiter, after having carefully listened to these orders, walks over to the kitchen and yells "One steak." This is a very fair example of how many specifications are carried out and how engineering materials are blamed for the lack of carrying out the orders carefully.

NOT MANY PRESERVING MATERIALS OF VALUE

It is not my purpose to give any specifications for the various types of waterproof and chemicalproof materials now on the market for the preservation of portland cement concrete; but suffice it

to say that there are not very many materials on the market which are completely meritorious, and the negative attitude in times gone by of the Bureau of Standards is to my mind largely due to the fact that several materials have been exploited which have been without merit. In fact, unless a man is scientifically trained and knows the reactions that may take place when various materials are subsequently stored or come in contact with concrete, he cannot devise a material which shall fulfill the purpose, but fortunately, as these materials are found out and found wanting, they from time to time disappear from the market, but in the meantime they harm directly and indirectly those compounds which have shown and proven their efficacy. I have a case in mind where one of the foremost architects in the United States has condemned all materials on account of failures which he has seen made with materials which should not have been used.

TYPES OF WATERPROOFING USED IN CHEMICAL INDUSTRIES

The following, in a general way, are the types of waterproofing used in the chemical industries:

First.—The integral type, which is used in the form of a dry powder, and the action is to densify the concrete, give it colloidal properties and to lubricate the mass while pouring. There are a large number of paste aqueous materials on the market, some of which are a kind of soap. Generally speaking, these soaps are to be avoided.

Second.—The next type well-known is the varnish type, which depends for its reaction on acid resins and has proved itself waterproof, oilproof and wearproof.

Third.—The third type is the fluo-silicate type, which in conjunction with the acid resin type or the bituminous coating type, where a proper bond can be effected, has given most excellent results.

There are, of course, modifications of these types, and I have in mind the building of the first storage building for niter cake large enough to hold a thousand tons, in which the concrete, after two years, has not shown the slightest disintegration. Another modification of this type is used for the building of concrete foundations along waterfronts where the water is decidedly acid and it is quite obvious that unless the concrete is properly treated the sol-

vent action of acid water would erode and dissolve away the concrete in a short time, and yet under proper treatment such foundations have stood up without showing the slightest sign of decay or disintegration, and the manufacturers are all aware of the fact that concrete may be constructed which is proof against acid fumes, and a number of these buildings are all in successful operation.

FUMES AND CLIMATE WRECK BUILDING MATERIALS

We must bear in mind that civilization is the great destroyer of our building materials. In the balmy air of southern Italy, where temperature changes are not very great and where the people still burn wood, and very little of that, and that only for domestic purposes, the masonry construction of the Roman Aqueduct has stood for two thousand years without disintegration. The same is true of the masonry construction of Egypt, yet we know that our obelisk, after having stood for twenty centuries in Egypt, began to disintegrate after it was erected in Central Park in New York, due first, to the climatic changes, and secondly, to the sulphuric acid in the air. I had occasion to examine most minutely the Tomb of Perneb after it arrived and was set up at the Metropolitan Museum of Art in New York. This tomb was built 4500 years ago, and the stones were in perfect condition when they arrived, but the atmosphere in New York soon began to produce an excrescence, due entirely to the foreign substances in our atmosphere. In 1913 I had the pleasure of seeing a large number of oriental building stones in the tombs that were taken from ancient Memphis in Egypt in the British Museum, and some of those stones which had been reconstructed in their original form had, absolutely, whiskers on them, calcium salts which the air of London had produced. The same is true of the monumental buildings of London, where, as long as there were no factories, the great buildings showed no signs of decay, but when London began to burn soft coal and belched sulphurous and sulphuric acid into the air, the building stone and cement construction immediately showed signs of decay and deterioration. This condition is of course amplified by the ordinary fumes in a chemical factory itself, and it is very fortunate that through modern methods of skillful investigation portland cement can be made to resist these conditions. Railway engineers are recognizing this all over the country, and where locomotive blasts

belch forth their fumes against concrete bridge arches, the arches are treated so that they will withstand the onslaught of chemical vapors.

I might also tell you with reference to that, that some man without any fundamental education but simply with God-given sense invented a material for protecting these arches on bridges, which is really sensible. These arches, of course, were painted, and that paint would not last any great length of time with a locomotive passing underneath. This man said it was not a serious problem. All you have to do is to put a wooden support underneath, just some boards 8 by 10 feet, and let the locomotive blast strike these boards. When the boards are used up put in new ones. That is really the method that is used to-day for that purpose.

METHODS OF PROTECTION

Briefly summed up, the methods for the protection of concrete against erosion, chemical action, disintegration and decomposition are as follows:

First.—The well-known membrane method, which consists, usually, of applying tar, asphalt or other bituminous materials, in conjunction with a membrane such as felt, burlap or textile fabric of any kind;

Second.—The brush application on the exterior of a concrete construction of a hydrocarbon material which is neutral;

Third.—The brush application of an acid resin which combines with the lime of the concrete and forms an integral material on the surface only;

Fourth.—The addition of a dry powder not to exceed 2 per cent, to densify concrete and to make it waterproof;

Fifth.—The addition of an integral powder to the concrete, to make it acidproof and alkaliproof;

Sixth.—The application of a brush coating or spray of a silico-fluoride, which precipitates silica into the interstices or pores of the concrete and makes it proof against oil and water;

Seventh.—Coating the concrete structure with two solutions which interact and precipitate and form an insoluble residue which prevents penetration of chemical compounds.

With regard to the last one I heard that the United States Government employed a man unquestionably of considerable

ability to design a method for making concrete tanks in which nitric acid could be stored, and this method was to use an alkaline silicate mixed with very finely divided barium sulphate. This was shot on the exterior, with considerable force by means of a cement gun and up to date I understand that these tanks have withstood the action of nitric acid perfectly. Of course you could not put sulphuric acid into a tank of that kind. I don't know whether it is generally known, that barium sulphate is one of the most insoluble substances. Strange to say, it is very easily and readily soluble in strong sulphuric acid. That now is really one of the bases of the analytical method for determining barium sulphate.

This, in a general way, is the practice of the present day, and sometimes two or more methods are used where the concrete is subjected to extraordinary conditions, but sufficient work has been done on this subject to enable chemical engineers to state with a considerable degree of assurance that concrete, which ten years ago was regarded as unfit as a building material in the chemical industry, can to-day be so manipulated that it has taken its place as one of the best, if not the cheapest, and most enduring material in chemical engineering.

DISCUSSION

The PRESIDENT: Is there any discussion of this paper?

Dr. WESSON: I have had a little experience with concrete used for storing cotton seed oil in tanks. About twenty-five years or so ago a man down in North Carolina built some large tanks, put them down in the ground and lined them with a plaster of portland cement. He put about 5000 barrels of oil in one of those tanks and when he came down one morning found a lot of the oil had gone. It just simply disintegrated the portland cement and seeped into the ground.

The PRESIDENT: Any further discussion?

Mr. HILTON: I would like to ask Dr. Toch if he has done anything in conjunction with concrete tanks for the storage of acetic acid, the problem that confronts us.

Dr. TOCH: Yes, sir. It is a strange thing that acetic, citric and tartaric acids are more corrosive and dissolve concrete quicker than a mixture of nitric, sulphuric, hydrochloric or any other acid you can make. It is simply remarkable how these organic acids de-

stroy concrete. We have had the experience in the laboratory. We have tried to make citric acid determination in a silica crucible and found we got 114 per cent because the citric acid would take up a good deal of the silica. The problem has been worked out of putting the interior of the tank on a foundation which I referred to in my paper, against the drippings of acetic acid and it is very difficult and one that has to be renewed about twice every eighteen months.

Mr. PETERSON: I would like to ask Dr. Toch if he has had any late information concerning the oil mixed concrete methods devised by the late Logan Waller Page, of the Bureau of Roads. The Treasury Buildings at Washington I believe were waterproofed with that mixture and have withstood successfully a considerable hydrostatic head. I think it amounts to six or seven feet. I would like to know if he knows of any late development.

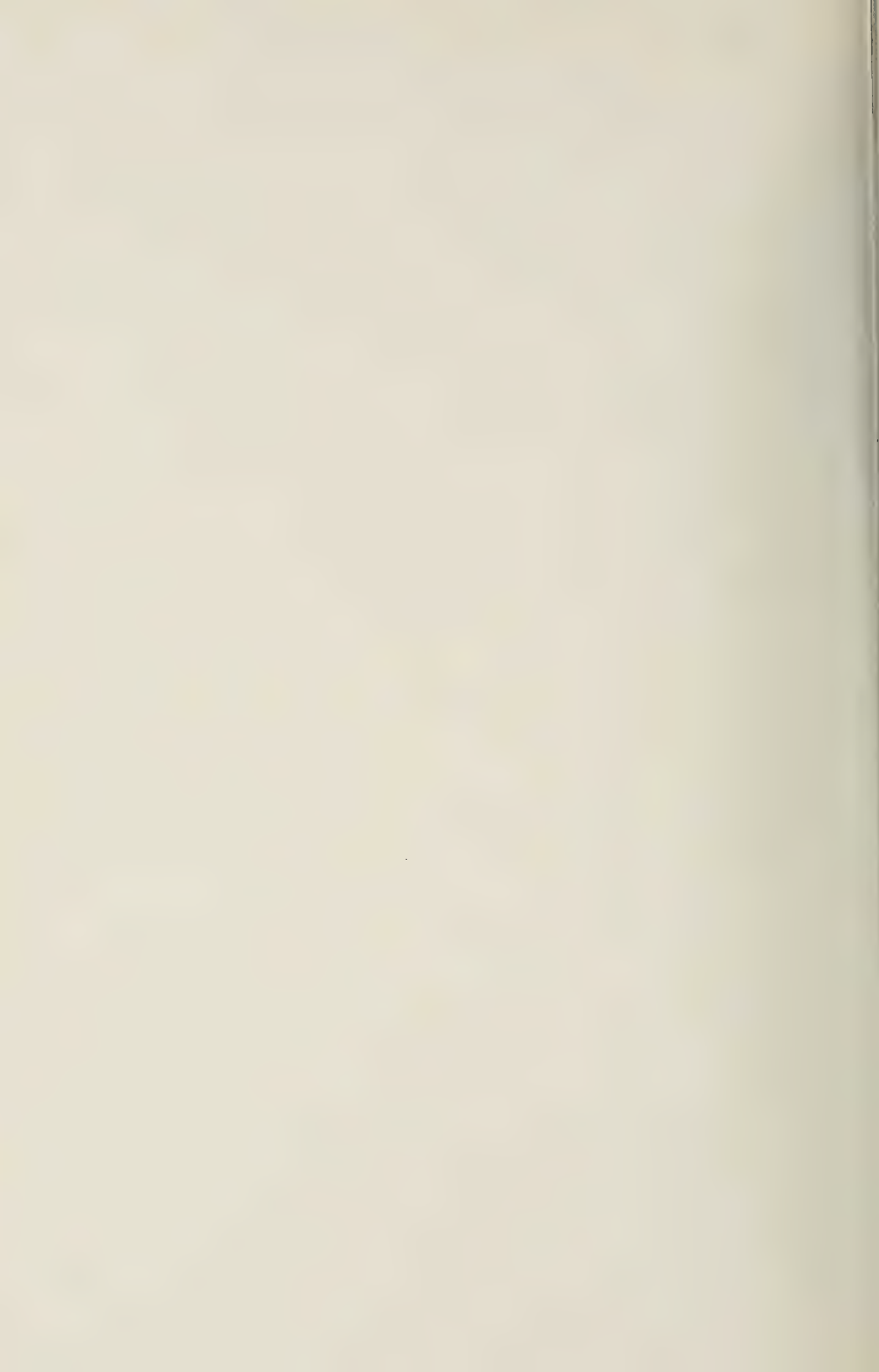
Dr. TOCH: I do not think any private corporation has done that. Sometimes you get a waterproof concrete but a very weak concrete, as the result. The work that was done on the buildings of the Treasury Department was done by Logan Waller Page about ten years ago. They have stood very well up to now. The tensile strength or compressive strength of a structure of that kind plays no rôle. Suppose you built this entire side wall in here and reduced it with 50 per cent additional aggregate. If there is no compression to speak of, no tensile strength to speak of, as long as the water head is kept out it will stand forever, but you could not build a railway arch that way and you could not build a chemical tank in which the hydrostatic pressure would be 15 feet say. I do not know of any Logan Waller Page method outside of that which the Government has used some ten years ago.

Before closing the subject of my paper might I claim the indulgence of the meeting just for one moment and extract a word from Dr. Frerich's paper on the storage tank method of reinforced concrete. I have just glanced through this and I find it is a very able article. To prove what I said, the whole tone of my paper that reinforced concrete is not sufficient if the concrete has simply been poured and placed in position but that you must do something to it if you want to use it in connection with chemicals, I quote:

"After the concrete work was completed and the tanks dried

out; the bottom, sides and roof on the interior were coated with three coats of tar applied with a brush as an additional precaution against leakage of liquid gas."

This shows the necessity of putting on a protective coat of this kind and also carried out the statement that I made that bitumen is one of the types necessarily used in the chemical industry.



REPORT OF COMMITTEE ON CHEMICAL ENGINEERING EDUCATION

Berlin, New Hampshire Meeting.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS:

Gentlemen:

The Carnegie Foundation for the Advancement of Teaching report upon its study of engineering education was expected to be issued shortly after the last meeting of the Institute. It has been delayed and has not yet been issued. There has been sent to the Chairman of your Committee as a member of the Advisory Board on Engineering Education of the Carnegie Foundation, however, a copy of a "confidential proof subject to revision" of the Foundation's Bulletin on Engineering Education. Besides being subject to revision, to it the Advisory Board is to add an introduction. This has not yet been completed. The Bulletin is to be entitled "A Study of Engineering Education by Charles Riborg Mann for the Carnegie Foundation." This publication covers 125 closely printed pages, magazine size, and is divided into three parts of sixteen chapters and an appendix, as follows:

Chapters PART I. PRESENT CONDITIONS.

- I. The Development of Engineering Schools in the United States.
- II. Aims and Curriculum of the Early Schools.
- III. The Struggle for Resources and Recognition.
- IV. Development of the Curriculum into its Present Form.
- V. Methods of Administration in Engineering Schools.
- VI. Student Elimination and Progress.
- VII. Types of Instruction in Engineering Schools.

PART II. THE PROBLEMS OF ENGINEERING EDUCATION.

- VIII. Admission.
- IX. The Time Schedule.
- X. Content of Courses.
- XI. Testing and Grading.
- XII. Shopwork.

Chapters PART III. SUGGESTED SOLUTIONS.

XIII. The Curriculum.

XIV. Specialization.

XV. Teachers.

XVI. The Professional Engineer.

APPENDIX.

Samples of the Thorndike Tests.

Bibliography.

Your Chairman expects to carefully study and digest the contents of this proof and has already partially done so and will submit a brief abstract of the contents with comments as soon as the material is released for publication which should be before the winter meeting.

A cursory reading of the contents of the Mann report indicates that he has left to the future any deep study of what might be called technical subjects and their manner of presentation. He has, however, gone to the questions underlying and, perhaps, more fundamental, i.e., the development of the teaching of engineering into its present phases and the reasons therefor; also the student material upon which the engineering education must be bestowed and the problems involved in pioneering this ground to make it capable of bearing fruit, after the application of the latter technical courses.

There will be differences of opinion and disagreement with conclusions and illustrations. The writer certainly does not agree with all he has read in it, nevertheless, the work must be of permanent value to those in charge of such work in our schools and colleges.

Respectfully submitted,

JAMES R. WITHROW,
Chairman.

The VICE-PRESIDENT: You have heard this report. Is there any discussion?

(Report, on motion, accepted.)

REPORT OF COMMITTEE ON CHEMICAL
ENGINEERING EDUCATION

Chicago, Meeting, January 15, 1919.

At the time of the last meeting of the Institute preliminary proof of Dr. Mann's Report to the Carnegie Foundation on Engineering Education was partly in hand. We were able to report to the Institute the main topics of Dr. Mann's discussion. Since that time there has been added to Dr. Mann's Report a prefatory chapter by President Pritchett of the Foundation. An introductory chapter by the joint advisory Committee on Engineering Education representing the Society for the Promotion of Engineering Education and the various institutes of engineering including our own American Institute of Chemical Engineers, has also been added.

In spite of delays to be expected in war time and the fact that Dr. Mann has been busily engaged in Washington on the educational work of the War Department, the completed report has recently been issued in final and permanent bulletin form by the Carnegie Foundation for the Advancement of Teaching. It is entitled "A Study of Engineering Education by Charles Riborg Mann, Bulletin 11, 1918," embracing 139 pages. The chapters are the *same* as those transcribed from the proof-sheets in the report of this Committee presented at the last meeting. To this has been added 11 pages including the two introductory chapters mentioned above.

As soon as a copy of this bulletin in its final form was received, your Chairman made arrangements with the Carnegie Foundation and the Secretary of our Institute that the Foundation should deliver copies of this report to any and all members of the Institute who signify their interest in the same. It was agreed that the members should notify our Secretary, Dr. Olsen, and that he would certify this list to the Foundation who would mail copies to the applicants. Arrangements were then made to have the Carnegie Foundation send a copy at once to each member of your Committee, who were notified of the request. These arrangements were made in the midst of the preparations for this meeting, notice of which announced the availability of the Car-

negie Report. It has not been possible for those individual members of the Committee who were not previously in possession of the Carnegie Report by virtue of being a member of the Society for the Promotion of Engineering Education to have time to adequately digest the Mann Report so that a discussion could be prepared which would represent the personal study of the Committee. In addition to this, but few members of the Institute have yet had opportunity to inspect the report and be thus prepared to adequately discuss it.

In view of these facts, it appears that no fruitful discussion at this meeting should be expected on the basis of merely a survey such as has been prepared by your Chairman or even a possible survey and discussion by your Committee itself. It appears wise, therefore, to delay final presentation and discussion until there can be suitable grounds for the same by the membership, arising from their personal acquaintanceship with the report of Dr. Mann. Such should be made a feature of the next meeting.

It is therefore urged by your Committee that each member signify the abiding interest in chemical engineering education for which our Institute has stood from its inception by demanding his copy at once and reading this bulletin of the Carnegie Foundation and this for the double purpose of becoming acquainted with the historical setting upon which engineering education in general has been built in this country and also to become acquainted with the methods of teaching the fundamental subjects, some of which are quite novel and very suggestive, which have been advanced by Dr. Mann as a result of his observation and studies in institutions themselves and be prepared to express opinions thereon from your own experience to your Committee. Finally, it is important to become acquainted with the growth of the ideals which have been developed in the course of the years in the engineering profession itself.

We ask that the acceptance of this report be construed as instructing the Secretary to take a census of those attending this meeting who desire a copy of this Carnegie Bulletin and to send out a return mail card requesting the membership to give the requesting of a copy of this bulletin their immediate attention.

Since the last meeting there have been two notable events concerning which mention should be made. One was the joint meeting between the British Education Mission and the Society

for the Promotion of Engineering Education and representatives of various engineering institutes and colleges of engineering in this country, for the discussion of the topics "The Liberal Element in Engineering Education," "The Effect of the War on Technical Education in the United States and Great Britain," and "The Organization of Technical Education in the United States." The meeting was held in Boston on December 6th and 7th. Your Chairman and Dr. Little were appointed delegates but both were unexpectedly prevented from attending. The Secretary of your Society, Dr. Olsen, however, was able to attend. Dr. Olsen informs the Committee that the discussion was of a general international character only and no results developed beyond the increasing of the cordial relations which we all hope will keep extending between educational factors in this country and those in Great Britain.

The other event which should be noticed was the *commendable* effort made by the War Department to enter the educational field by establishing the Students' Army Training Corps, commonly known as the S. A. T. C. The sudden and happy termination of the war caused this program to be abandoned within about two months of its inauguration. It is difficult to state what the final results would have been from the program but it seems certain on its face that the matter was poorly digested. There was not proper co-ordination between the objects of the War Department and the objects which the institutions of learning understood they were to carry out. In the technical subjects at least, no adequate attention at all was given to the preparation of proper curricula. It could not have been more poorly done if the curricula of some single institution had been clipped from its catalog and all other institutions ordered to conform thereto. Request was made by the Head of the Chemical Department of a large university who was made acquainted with the proposed program by the War Department Educational Committee to lay their proposed chemical engineering curricula before a number of the experienced teachers of chemical engineering subjects then in Washington in war service but this request was ignored.

The military end was grossly mismanaged in the sense that no proper organization for the handling of large numbers of students was furnished to those who were put in charge of the work and the failure in management by the War Department was

particularly noticeable in that these military officers did not themselves know and were not instructed to avail themselves of the different university registration and organization bodies who have had years of experience in the handling and organizing of student schedules.

Weeks of the precious training time of thousands of embryo (student) officers were thus needlessly wasted in a time of emergency which might have been serious. It is to be hoped that those in charge will be so impressed with the chaos their methods produced that they will leave behind tangible directions for any future emergency of the kind.

This Institute would be remiss if it did not gratefully acknowledge our thankfulness that by education and experience many chemical engineers both within our membership and outside it, have found themselves prepared to render service in our war task of the *last four years*. The educational institutions of the country were not far from the front rank if we were to rate preparedness. Everyone of them contributed through its men and its faculties, some in greater, some in lesser degree as they were given opportunity. We are glad to say no one institution had a preponderance either of heart in the work or even in actual service. Some had naturally more men in one line of war service and others in still different lines. Some were in the military and some kept the wheels going. If any were uncharitable or seemed unfair in taking advantage of positions or opportunity to push their graduates into positions of honor or carry off more military commissions in chemical work than rightly belonged to them by fair proportion, it is the shame of individuals and should not be laid to the door of the educational institution, for none of these need such doubtful honor and certainly cannot have their educational value to the country increased by the grabbadocio that would arise from such efforts. Even in these honors no one institution excels its neighbors. If it did, it would be a matter for self-inquiry on its part, to see whether it really deserved the distinction or merely was the shameless victim of its own sons. The performance was not always good in the service rendered but we speak of the spirit of desire to help or step aside for those more experienced, which animated the vast majority of those in active chemical war service. With these things behind us, the nation must in turn support chemical education as it has never done before.

The war is over. We are all so happy that the war is over we want to forget the whole nightmare. We have so much to be thankful for in being saved so quickly from war's horrors and from our own desperate and frantic efforts. Our celebration of recovery from war times brings us to the stage where our Institute is commencing to realize on the efforts of the founders, to stir up interest in chemical engineering education. You will remember they made this one of the prime interests of the organization from the very start. It was in the air. The industries everywhere needed attention directed to their needs from education. Any teacher in our Institute and in fact any teacher who has followed the discussions cannot fail to have received help unless he was not actively enough in touch with manufacturing to understand the need or else he was so sure he followed the only possible program that he was not open to self-examination. It is a fair conclusion that our discussions, crude as they were or may appear to a superficial inspection, have been of educational value.

Institutes of other kinds of engineering also were stirring up themselves at the same time on this subject. When we appealed to the interest of the Carnegie Foundation for the Advancement of Teaching we were acquainted with this and invited to join a general movement toward looking into the suitability of the general foundations of the engineering curriculum as commonly accepted in our engineering schools.

The results of this joint investigation are more thorough than could have been carried out on this phase of the subject by our Institute alone. They are before you. Let every member of the Institute study this Carnegie report. We owe it to our profession and to the responsibility financially reposed in that profession by our common country. After we have the educational situation in mind from Dr. Mann's report let us see what we can get out of that report in view of our personal experience, to help chemical engineering education, to help our profession, to help us in our individual problems and relations. Let us see what the report suggests as our next step.

We cannot afford to overlook any help to education. Let us not name the atrocities committed in the name of chemical engineering in the last four years, but ask ourselves what other group of industries than the chemical ones expanded in exports above 540% in that time? The real chemical engineer evidently

met the supreme emergency. Let's give him educationally all the support we can.

HERBERT H. DOW,
J. H. JAMES,
JAMES R. WITHROW,
Chairman.

The PRESIDENT: Is there any discussion of this interesting report?

Dr. GUDEMAN: Mr. Chairman, as I understand the report, there is a suggestion made there that the Secretary communicate with the members telling them to get a report.

The SECRETARY: I have already done so.

Dr. GUDEMAN: I know you have done so. I would like to ask Prof. Withrow whether he would not consider it good to add to the report just a brief abstract of the preface in which the objects are so forcibly and well stated by President Pritchard. I believe that that quotation would help. I especially refer to the third paragraph which I believe ought to be called to the attention of our members and which will induce them possibly to study the report starting in with, "In the half century that has passed this course of study has been overlaid with a great number of special studies." There are about ten, fifteen or twenty lines there, and then one of the very concluding paragraphs. I think not enough importance is given to the suggestion of President Pritchard. When this report is discussed I believe in incorporating and quoting just the third paragraph and the final paragraph of President Pritchard's introduction. That I think would give our members an idea of what this report is. I speak from personal experience. When I tried to discuss this report with some chemical engineers and chemists they felt it was exclusively engineering, and they did not see the great importance of its application to all chemistry, all chemical industry. You can't get away from the engineering. I would ask Prof. Withrow whether he would object to introducing that third paragraph and the final.

Dr. WITHROW: We certainly would be glad to accept that suggestion.

The SECRETARY: Professor Withrow has mentioned the S. A. T. C. in not very complimentary terms. I had a similar experience and could add to his remarks. I attended the meeting in

Boston of the Society for the Promotion of Engineering Education where we had not only the British Commission which is here looking over engineering schools to see what they can learn, but we also had General Black, Chief Engineer of the United States Army, who represented the Government on this matter. The officers in charge of that meeting seemed to fear that on the floor of the assembly uncomplimentary remarks might be made about the S. A. T. C. and the army's method of trying to get officers and engineers trained at the same time, and did not wish uncomplimentary remarks to be made with reference to the lamentable failure, and so we were told from the chair that there had not been sufficient experience with the S. A. T. C. and that plan of getting army officers to warrant any conclusion for or against. The body present took the hint and did not say anything on the floor about it. The same statement should be made here because the question has been raised. Perhaps if we had had more time we could have worked out some of the difficulties that came up and might possibly have secured better results. But it certainly in many ways was a lamentable failure. So far as we were concerned, at the Polytechnic Institute at Brooklyn, we did not adopt the Government program, so far as the technical education was concerned. We took our own program and modified it as much as we thought best and gave the army officers the time which the Government said they should have. Of course, they took a lot more than they should have, but that is another matter. We did not take the program as sent us from Washington. We understood we were allowed to modify it.

With reference to this report, I have already sent out a letter and I have received a good many responses and have asked the Carnegie Foundation to send Dr. Mann's report to many of our members, and other members here who have not received the report and who wish to receive it, can let me know during this meeting and I shall see that you get a copy of this very important report.

The PRESIDENT: Are there any further remarks? If not the report will be received with the thanks of the meeting.

SOME WILD ENGINEERING I HAVE KNOWN

By DAVID WESSON

Read at the Chicago meeting, Jan. 17, 1919

Many, if not most, of the troubles in this world come from lack of knowledge of the natural laws and their proper application to practical problems. The theories of practical men are often examples of the old saying that a little knowledge is a dangerous thing. It sometimes leads to wild conclusions, as in the case of the Irish foreman who was seen thoughtfully studying a light foot-bridge between two buildings about 60 feet apart. Resting on the bridge was a three-inch steam pipe. On being asked what the matter was, the foreman said, "That pipe carries 80 pounds of steam to the inch and 960 pounds to the foot, and the bridge is 60 feet long, which figures to 57,600 pounds, and I'm after thinking that must be an awful strong bridge."

The above incident happened before the days of chemical engineering and the chemist who worked out from his laboratory into the plant had to depend on the plant engineer to put his ideas into practice. In those days the plant engineer was more likely than not a man who had graduated from the machine shop and engine room, with a very hazy idea of physics but a strong reliance on his practical experience and ability to guess. When such a man and a chemist started to design a plant it was often a case of the blind leading the blind, and things were created which sometimes worked and sometimes did not. Difficulties arising from such causes naturally set the scientific minds of the chemists to looking into the causes, and after a proper diagnosis it was comparatively easy for the chemist to design what was needed and let the mechanic do the actual construction work. This, in the writer's opinion, was the genesis of the chemical engineer.

SOME COTTON OIL REFINERIES

The writer had the privilege in 1887 of visiting most of the pioneer cotton oil refineries of the country. They were built by mechanics, not chemists, and varied greatly in design and construction. One plant was equipped with cylindrical tanks with flat bottoms and agitated with paddles revolving on a horizontal axis passing through the walls of the tank. The soap stock formed in the process of refining was drawn off as much as possible from the flat bottom after each refining, and what was left went into the next batch.

Another refinery showed with pride a large tank made to refine 400 barrels at one batch, but they never worked it more than half full because the heating coil was too small to heat the oil rapidly enough, though sufficiently large to condense all the steam from the entire boiler plant.

A refinery in New England noted for the fine quality of its oil did all its work with 1½-inch pipe lines and kept small pumps going 24 hours per day to handle comparatively small quantities of oil.

About 1888 or 1889 a new company put up five large oil mills which were equipped with Abendroth Root high pressure water-tube boilers and Brotherhood engines sprinkled about the large barnlike mills. Pipe covering and insulation were considered useless luxuries, and naturally the mills did not operate very successfully. The engines were natural steam hogs, and the overworked boilers were always breaking down. The management had to change the type of boilers and install central power plants with Corliss engines before their mills were put on a paying basis.

TUGBOAT ENGINEER "EXECUTES" DESIGNS

Some years after this the writer was called upon to design a refinery for the same company. The chief engineer boasted a United States license to preside over the engine room of a tugboat, and knew it all. He was given the design, and when the construction was finished the writer visited to plant to start it. He found all the valves and cocks controlling the pipe lines so placed that the pump man would have to spend most of his time on a ladder to get at them, but the most remarkable thing was the in-

stallation of a tubular feedwater heater of 250 H.P. capacity installed for cooling hot deodorized oil. That engineer could not get it through his head that this was not big enough to cool down 20,000 pounds of oil from 300° F. to 100° in an hour's time. He knew that the heating tank contained about 500 square feet of heating surface in the form of coil, while the feed water heater had about 80 square feet. Of course a trial convinced him, and the day was saved by making water connections with the heating coils and cooling the oil right in the tank instead of pumping it through a cooling coil. The same engineer failed to provide a water trap in the steam line carrying steam to the deodorizer, and one day a slug of water was carried into the hot oil and the contents of the tank were blown up the steam outlet pipe and distributed over the neighborhood as a rain of oil in which the observers saw a most marvelous rainbow caused by the rays of the setting sun impinging on the highly refractive oil droplets.

The experiences with the feed water heater may be considered typical of mistakes made in the application of heat. The mistake has been made on more than one occasion of trying to heat oil and other liquids in kettles supplied with low pressure superheated steam, the fact being overlooked that the chief value of steam as a heating medium is the latent heat of condensation, while the sensible heat of superheated steam is little better than that of so much hot air on account of the comparatively low specific heat in the steam and the comparatively small weight of steam usually delivered at given pressures.

This brings up the use of exhaust steam for heating tanks. I remember seeing a very expensive installation for that purpose in England. It was calculated that by using the exhaust from an engine a great saving would result. Theoretically the saving should have been made, but practically the engineer tried to deliver the same weight of steam at 5-pound pressure through a 2-inch coil as would have been delivered under normal conditions through the same coil with steam at 80 pounds. Of course it did not work.

FUNNY THINGS SEEN IN PIPE LINES

In running pipe lines funny things happen sometimes. I remember seeing in a certain plant in Germany a pipe bent on a

beautiful curve on a 3-foot radius and connected into the sharpest kind of a right-angled elbow at one end of the bend.

In a plant at Memphis some years ago a filter press was located in the top of a refinery, and the 4-inch pipe line to carry off the filtered oil to storage tanks 100 feet distant was run by the engineer in charge with a 4-foot drop straight to the storage tanks. When the filter pump was started up the pipe line was found too small to carry off the oil and the pan overflowed. Of course the plant was practically tied up till a chemist arrived on the scene and ordered the pipe line dropped to a horizontal position and connected with a 3-foot vertical pipe from the filter trough. In the first case a straight line though the shortest distance between two points did not have more than a 6-inch of head to force the oil through it, while in the second case there was a little over 3 feet of head and the oil ran off freely.

Engineers who should know better design large tanks to be heated by steam jackets instead of suitable coils. They do not realize that it is impossible to get sufficient heating surface in jackets, nor do they consider the danger in working with jackets at high pressure.

TO PREVENT FIRES—DON'T BUILD

In a Southern city some years ago there was a plant engaged in distilling rosin to make rosin oils. Fires were frequent, and the cheap frame buildings over the stills were burned down. Finally the brilliant plan was evolved of doing the work out of doors. After that they had no more conflagrations but in cold and rainy weather the stills did not work very well. Some neighboring manufacturers engaged in distilling fatty acids tried the same scheme. The stills were out of doors, the condensers were in a fireproof house. There were no fire damages to be paid for by the insurance companies, but the quantities of fuel used in cold and wet weather, the large amount of fat converted into tar, the lost time and repairs soon amounted to several times more than a house over the stills, which was eventually built during the absence of the general manager, with the result that the plant became more profitable shortly afterward.

A mistake frequently observed is the design of tanks to be used under vacuum with too light materials, with the result that they collapse when put in use.

All of us looking back over our experiences can think of many other examples of wild engineering leading to more or less disastrous results. The foregoing cases are sufficient to illustrate the ease with which people who should know better are apt to transgress physical laws, which are capable of demonstration. The results, while bad enough, are infinitesimal as compared with those obtained by some of our elected statesmen, who often from ignorance and often for the sake of votes take great liberty with social and economic laws and commit social and economical engineering atrocities. The law of supply and demand, for example, is as immutable as the law of gravitation, but how often have we seen it defied by Government officials. We can hold back the flood of a watercourse for a time by constructing a suitable dam, but sooner or later if the water supplies keep increasing the dam will either overflow or be carried away and destruction will result.

WILD "ENGINEERING" BY LEGISLATURE

The prices of labor and materials of all sorts can be maintained at unnatural levels by war-time restrictions, as we have all seen, but the moment war-time conditions remove the prop from the dam, unless suitable channels are constructed to reduce gradually and safely the pent-up level of the flood, disaster is bound to ensue.

When one sees legislators passing laws preventing the formation of large industrial and transportation aggregates, it would seem that a lesson might be taken from the courtiers of King Canute, who imagined that a word from the governing powers would prevent the rising of the tide when they placed the King on his throne upon the beach.

The lesson we must all learn from the war and the period preceding it is that the day of co-operation is at hand. By the co-operation of nations the common enemy was defeated. By the co-operation of railroads and steamship lines in our own country transportation was speeded up. By the co-operation of industries production was increased enormously. Now that the war is over the need of co-operation is greater than ever. The so-called conflicting interests of labor and capital must be caused to co-operate in such a manner that our complex social fabric shall have all parts working in harmonious unison to make the most of our natural

resources and create again the enormous wealth destroyed by the war. This is the problem we all have before us and to which we will have to devote our best energies, both as worthy citizens of our great country and as members of our profession of chemical engineers.

BELTING FOR POWER TRANSMISSION

By ERNEST D. WILSON

Read at the Chicago Meeting, January 17, 1919

Belting for power transmission is one of the most widely used commodities in the industrial world, and I do not believe that there is anything of equal importance that is given as little attention. A belt is usually considered lightly. Although a great deal of trouble is usually taken in picking out the motor which will run the belt and the machine which is finally to be run, almost no attention is usually given to the belt itself. The main object of this paper is to call to your attention the importance of the belt and the varying qualities of the different types of belting which are now upon the market.

One of the most difficult problems which confronts engineers who have anything to do with power equipment is the proper design of belt drives. This difficulty is due to the fact that very little really accurate information exists as to the capacities of the various belts which are on the market. It is because of this that one is able to find in various engineering handbooks a large number of rules for power transmission by belting, none of which agree. One of the favorite methods of giving power transmitting capacities of belts is to name the velocity at which a 1-inch single belt will transmit a 1 H.P. A number of the handbooks referred to give ratings all the way from 475 to 1,200 feet per minute per inch of width required to give 1 H.P. None of the tables of the various belt manufacturers have taken any account of the additional strain applied to the belt by reason of its centrifugal force and hence their ratings are at fault in that belts at high speeds are under much greater tension than low-speed belts, when transmitting the same horse-power.

The situation is still further complicated by the fact that the same horse-power tables are used for all of the different belt materials in spite of the fact that it is common knowledge that the transmitting capacities of the various materials cover quite a range.

It is impossible to design drives with any degree of confidence without accurate knowledge of the proper ratings, overload capacities, etc., of various types of belting, and it was with a view to secure such data that the Graton & Knight Mfg. Co. established its Engineering Department and Laboratory some time ago. In this Laboratory an investigation of the power transmitting capacity of different belt material was undertaken but later the work was transferred to the Mellon Institute where it was supported by the Leather Belting Exchange Corporation. The Mellon Institute, being an endowed institution, is in an entirely independent position in regard to any work undertaken in its laboratories. It does not take the position of a lawyer, attempting to win a client's case, but agrees only to develop the facts, whatever they may be. Thus, although the work on belting was financed by the Leather Belting Exchange Corporation, the Institute was obligated to them in no way whatever and conducted the investigation in an entirely unbiased manner.

This paper is only a preliminary report of the investigation described, and contains only the general conclusions which were arrived at.

BELT TESTING EQUIPMENT

In order to make satisfactory tests as to the power transmitting capacity of belts it was necessary to run belts under conditions similar

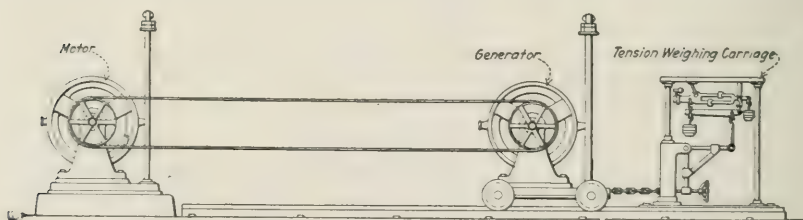


FIG. 1.—Belt Testing Machine.

to those existing in every-day practice. Consequently, the machinery had to be of sufficient size to allow horse-powers of 100 to 150 to be reached.

Data reported here was obtained partly on the Graton & Knight machines, and partly on the equipment later installed at the Mellon Institute. The Mellon Institute machines were designed along the same lines as the Graton & Knight testing machines with some minor changes and improvements.

The three essential parts of the belt testing machine used for conducting these tests are a motor to furnish the power, a generator to furnish the load, and a device to measure the tension of the belt. The arrangement of these three parts of the machine is shown in outline in Figure 1. Both motor and generator are direct-current machines and are capable of developing 150 H.P. They are known as electric dynamometers, and are manufactured by the Sprague

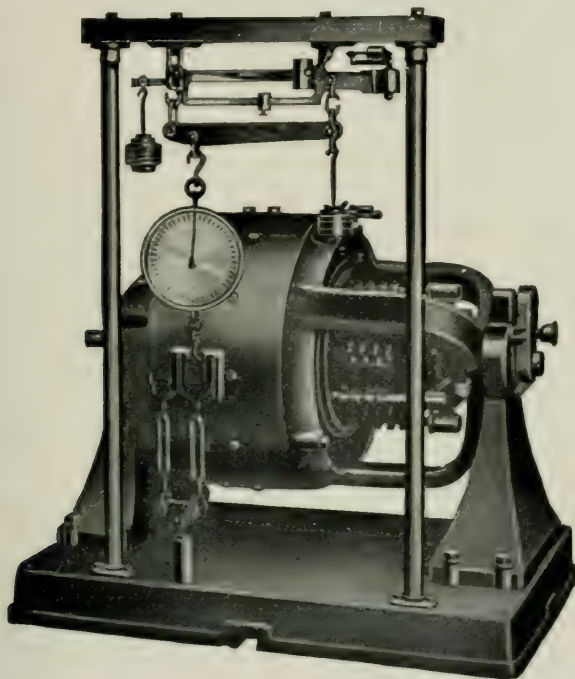


FIG. 2.

Electric Works. As can be seen from the illustration in Figure 2, the only difference between one of these machines and an ordinary direct-current motor is that the entire field frame is hung on ball bearings, so that when running, the torque which the motor is actually applying to the driving shaft is transferred by levers to a scale, where it can be weighed in pounds. By means of this arrangement for actually measuring the driving force applied to the belt, all theory was eliminated, and the data reported represent purely

experimental results. The power which the belt actually transmitted was measured in the same way by the generator, and the tension under which the belt was running was transferred directly to beam scales and weighed in pounds, as shown in Figure 1.

The control panel was equipped so that the speed of the motor could be accurately regulated, and the load applied to the belt by the generator varies throughout a range of 0-150 H.P. The speed was measured by two electrically operated revolution counters.

An outline of the conditions under which the tests were conducted follows:

Pulleys.—Cast iron, steel, and wood pulleys were used, and while differences were found, the results were near enough alike to enable them to be combined. All pulleys were 24 inches in diameter.

Drive.—The belt speed was varied from 2500 to 5000 feet per minute for a series of tests. The results reported were secured at a belt speed of 3140 feet per minute. The belt was horizontal and the tight side was on the bottom.

Tension.—The range of tension investigated varied from 45 to 90 pounds per inch of width when the belt was standing still. To insure duplication of results the belts were tested starting from a definite tension when the belts were running under no load. In the test reported a tension of 55 pounds per inch of width was used when the belt was running at 3140 feet per minute under no load, which is a little above the average tension recommended by the various manufacturers.

Belts.—The belts used were as follows:

Leather: all first grade single ply; 12-18 ounces.

Balata: 4 ply.

Solid woven cotton: single and double.

Friction surface rubber: 4 ply.

Stitched and filled canvas: 4 ply.

All belts were 4 inches wide and approximately 30 feet long. They were taken directly from stock or purchased on the open market, and no specially constructed or treated belts were used. A large number of leather belts were tested and several of each of the other types. All were first grade belts of their kind, and rated approximately the same by their makers.

In conducting the tests, the load of the belt was increased by steps of about $2\frac{1}{2}$ H.P. from zero to a point where the slip was at least 3%, or the belt showed signs of distress. Often a slip of 10%

to 20% was obtained. Readings of slip, speed, horse-power input and horse-power delivered by the belt, and the tension were made at each step. The tests were always repeated until the belt showed an approximately constant capacity. The conditions under which the various belts were tested were identical in every detail.

It was decided at the start to refrain from the use of dressings of all kinds, and this was consistently adhered to. Furthermore, the belts were run for a sufficient length of time to eliminate the more or less temporary effect of any sticky dressing applied by the manufacturer. Belts dressed with such dressings show high capacities at the start, which rapidly diminish as the belt picks up dirt and the dressing hardens and chips off, but any such temporary capacity is a property of the dressing, not of the belt.

RESULTS OBTAINED

The capacities of the various types of belts can be shown by plotting the horse-power transmitted at various percentages of slip as in Figure 3. These curves show the actual performance of the various belts from no load to the maximum obtainable without excessive slip. They do not state anything in regard to practical ratings.

All of the curves have been made from the data secured in a large number of tests. In the case of leather, the curve is more nearly a minimum than an average. A number of these belts show over 25% greater capacity than is indicated by the curve. In each case, however, the curves for the various substitute belts are the maximum or very nearly so.

It is apparent at once that all of the belts tested may be divided into two general classes according to the characteristics exhibited by the horse-power slip curves. The curve exhibited by leather belts is entirely different and distinct from the curves shown by the other types of belts. In fact all of the belts with the exception of leather exhibit the same characteristics and show the inability to transmit power when slipping over about $\frac{1}{2}$ %. For convenience all of the belts made of other materials than leather will be designated as fabric belts. The striking characteristic of all of the fabric belt curves is that they possess a very definite maximum capacity beyond which it is impossible to go. Before this point is reached they act efficiently and transmit power with very little loss, but when

loaded to the point where slip of approximately $\frac{1}{2}\%$ begins it is next to impossible to reduce it without cutting the load down to a

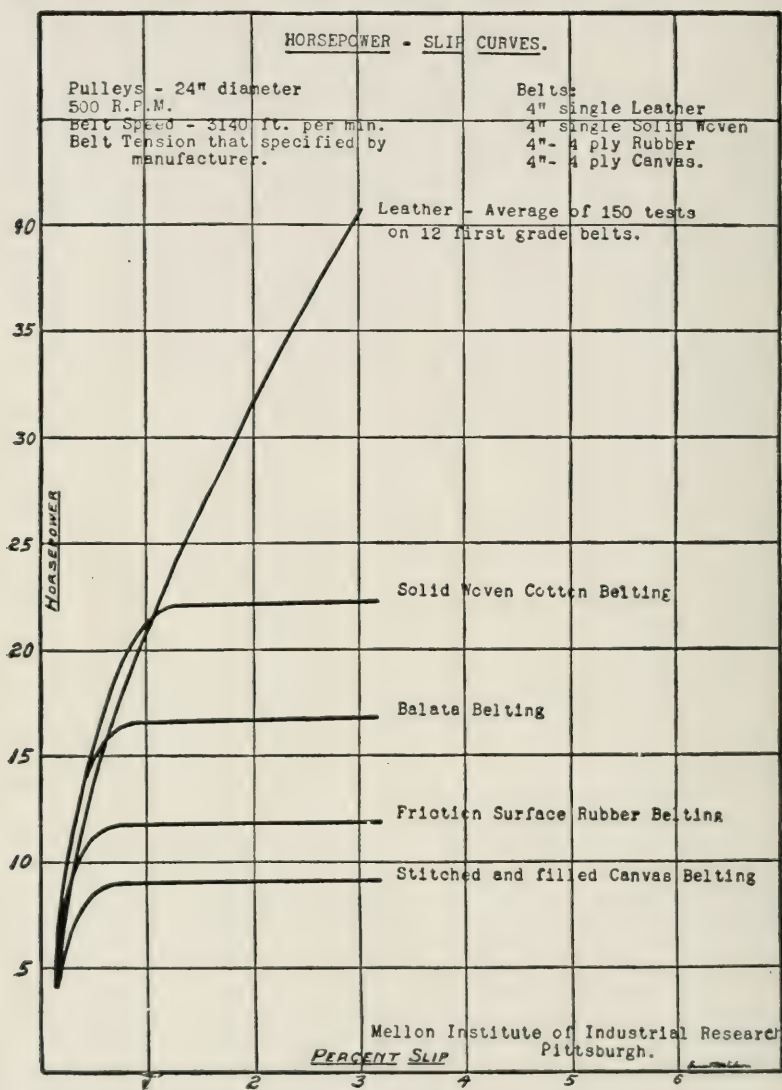


FIG. 3.—Horsepower Slip Curves.

comparatively small figure. It is evident that if the fabric belts are to be used they must not be called upon to transmit horse-

power in excess of their maximum capacities as shown by the above curves.

Leather belting under the conditions used in this test should be rated to transmit from 21 to 25 H.P. depending upon the thickness of the belt used.

The fabric belts tested are supposed to be equivalent to single

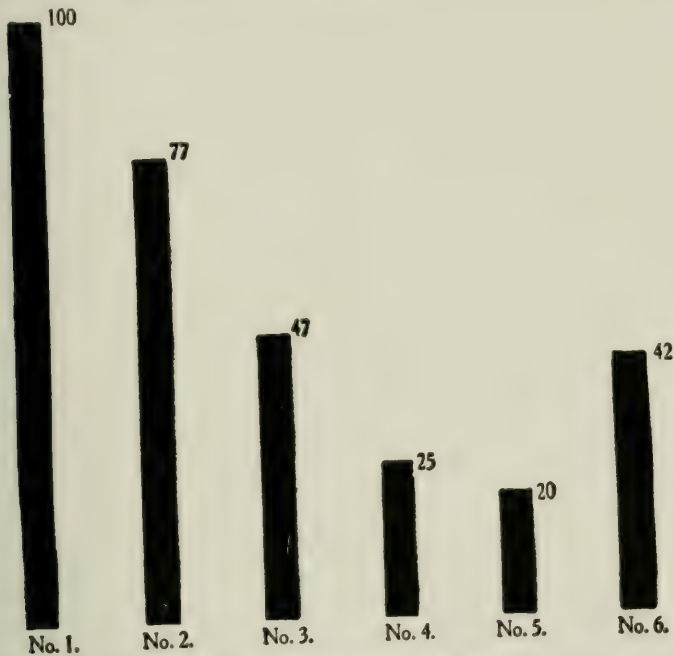


FIG. 4.—Maximum Effective Pull of Belts per Square Inch Cross-section.

Belt speed—3140 feet per minute

No. 1, average for first grade, single leather belting; No. 2, solid woven cotton belting; No. 3, balata belting—four ply; No. 4, friction surface rubber belting—four ply; No. 5, stitched and filled canvas belting—four ply; No. 6, average for the substitute belts.

ply leather belts of the same length and are so rated by their manufacturers. It will be observed that none of these belts transmit their rated horse-power and hence do not come up to their maker's guarantee. Leather belting at 25 H.P. under these conditions possess an overloading capacity of 60%, while the fabric belts, operating at much lower horse-powers, have no overload capacity whatever.

The capacities of the various belts may be shown in still another way which takes account of the thickness of the belts. The power

which a belt will transmit depends upon the effective tension which it is capable of developing, and hence a comparison of the maximum effective tension developed by the different belts is particularly valuable. These figures are shown in Table I. The comparison is still more effective when the leather is rated at 100 and the relative values of fabric belts are shown as in Fig. 4.

The result of these experiments prove conclusively that the cheapest belting material on a basis of the power actually transmitted is leather. It is unfair to compare various types of belts merely by their prices per foot, when it is the cost per foot per horse-power which is really of interest.

These tests did not take into account the well-known fact that leather belting has a much longer life than any of the fabric belts and that leather belt always improved with age and use while the others deteriorate. It was noted during the course of experiments that the best results obtained with the fabric belts were always obtained during the first test and the belts showed lower capacity in each succeeding experiment. In the case of the leather, however, the first test was almost always the lowest and every hour the belts were run, improved and increased their maximum capacity.

TABLE I

	Rated H. P.	Total Lbs. Effective Tension	Lbs. Effective Tension Per Inch Width.	Ft. Per Min. to Give 1 H.-P. Per In. Width.	Compar- ative Value Leather 100
Leather.....	25	270	68	490	100
Solid woven.....	16	175	44	760	65
Balata.....	12	130	33	1,020	49
Friction surface rubber.....	10	110	28	1,200	41
Stitched canvas.....	8	86	22	1,500	32

NOTE.—The above figures are safe ratings for the various belts for continuous operation on easy drives; i.e., 180° arc of contact, large pulleys, tight side on bottom and steady load.

The frictional qualities of the leather belts are so high that they do not determine the safe rated capacity of the belts because the maximum horse-power which the belts are capable of transmitting is far in excess of the safe rating figured on the basis of the tensile strength of the material. In the case of the fabric belts, however, the coefficient of friction is so low that the maximum capacity of the belt is entirely determined, not by the tensile strength of the material, but by the friction of the surface alone.

Further tests are in progress both in the Laboratory of the Mellon Institute and the Engineering Department of the Graton & Knight Mfg. Co., and it is hoped in the near future data will be available from which to construct a very complete set of tables, as a basis for the design of belt drives.

DISCUSSION

The PRESIDENT: Is there any discussion of this paper with regard to belting?

Mr. HOLLANDER: Mr. President, I should like to ask Mr. Wilson whether these leather belts were in any way treated to any water-proofing compound.

Mr. WILSON: The belts that we tested were not treated in any way. They were belts, such as you would buy on the open market at any store, plain, ordinary, oak-tanned leather belts. The belts when treated with water-proof dressings have just about the same characteristics, although they usually possess a little greater capacity than the untreated belts. We consistently refrain from introducing any more factors in the shape of dressings.

Mr. HOLLANDER: It seems to me it would be very interesting to compare the value of plain, ordinary leather belting with that which is claimed to be water-proof and acid-proof to a certain extent under all conditions, because I think we are all agreed that the leather belt is the best if you can spend the money. The only thing that has prevented a great many manufacturers from using it is that the leather has a tendency to deteriorate and the joint will come loose in any kind of damp atmosphere. In the presence of acid fumes the leather will get hard and that is one of the reasons why in some processes the people have to use rubber belting, for instance.

Mr. WILSON: There are drives where leather is not the most suitable material, as there are drives where the belts are exposed to strong acids, alkalies and so forth, and where any belt material, I don't care what you use, will be eaten up in a comparatively short length of time. Those drives, of course, comprise only a small per cent of the total number and in those cases it probably is the cheapest in the long run to buy the belt with the lowest first cost. On the other hand, in almost all cases, the reverse is true, and the reason that so many manufacturers buy other types of belting, because they say it is cheaper, is simply because they consider only the price per

foot. Now, as I have shown you, it will take a friction surface rubber belt twice as wide as a leather belt to carry the same amount of power, and if you consider the price per horse-power per foot the leather will always be cheapest. Now, in regard to water-proof belts of course you all know that there are a number of types of leather belts. We find on the market oak-tanned leather belts that are not water-proof in any sense of the word. Then we find oak-tanned leather belts that are water-proof. The cement which is used in putting them together is a water-proof cement. A great deal of the trouble that has come from belts in damp places is due to the fact that a water-proof belt was not used and perhaps only a belt that was treated with some dressing, while the cement was still a plain ordinary glue. A leather water-proof belt is exactly as water proof as any other type of belt on the market. As I said, while we did not use water-proof and dressed belts in these tests, we have made tests on them. We find they transmit about the same horse-power as untreated belts, very little more, but certainly not less.

Mr. BICKNELL: I understand these were oak tanned, were they not?

Mr. WILSON: Yes.

Mr. BICKNELL: Could you tell how a chrome belt would stand in those tests?

Mr. WILSON: There are some manufacturers who sell chrome tanned belts who claim and guarantee that they will transmit 20% more power than oak-tanned belts. As a matter of fact in the case of a large number of chrome belts tested they transmitted no more power at all than oak-tanned leather belting.

Mr. HOLLANDER: Did they transmit any less?

Mr. WILSON: No. They ran just about the same, not a great deal of difference.

The PRESIDENT: I would like to ask a question, I think that you stated that your motor and your generator had, each of them, 24-inch pulleys.

Mr. WILSON: Twenty-four inch pulleys, yes.

The PRESIDENT: Have you used smaller pulleys on the motor? The point I make is that with motor drives very usually the speed of the motors is so great that except for very high powers a 24-inch pulley is very unusual. Take up even to 100 H.P., you won't have very often a 24-inch pulley because you have to get a reduction of speed. Now with a smaller pulley the angle, the bend is very much greater.

Perhaps these are not the right words to use but at least you bend your belt a great deal more in going over the small pulley, and I am wondering if you will get the same results with small pulleys on account perhaps of the less flexible character of your leather belts.

Mr. WILSON: We have made tests on smaller pulleys than 24 inches. We made tests in cases where there was a considerable reduction, a small pulley on the motor and a large pulley on the generator, and we found in all cases *where a suitable belt was used*—I want to emphasize that point—that the comparisons given held almost exactly without regard to the arc of contact or the sized pulley. The reason that we used the larger pulleys was that we wanted all conditions the most favorable for the belts, and the comparison, of course, would hold true because all belts ran under exactly the same conditions. We did find that the comparisons were the same whether we had a 180° arc of contact or whether we had a 160° arc of contact.

The PRESIDENT: Is there any further discussion?

Mr. HOLLANDER: I would like to put some further questions to Mr. Wilson. Did you find that the ordinary joint on a continuous leather belt would stand for speeds greater than say 5,000 feet per minute, or did you find that a continuous, specially treated cotton belt would be better for those high speeds? I have bought some high speed machinery from manufacturers who claimed that a specially treated and specially woven cotton belt was more favorable and in the long run cheaper than the leather. We have never used it but that was the claim of the manufacturer of the machinery.

Mr. WILSON: I think that the highest speed belts in the country will be found at saw mills on side head drives of planers and things of that sort and I know of belts that are running as high as 9,000 feet a minute on some of those drives. Theoretically, they should not transmit any power at all, but they seem to. I could best answer that question by saying that in all the saw mills of the country over 90% of all the belts are leather.

Mr. BICKNELL: Was any comparison made between three or four-ply fabric belting and six-ply fabric belting?

Mr. WILSON: We used only the four-ply fabric belting because that was supposed to be equivalent to single leather belts. I would like to call your attention to the fact that the coefficient of friction of the surface of the different belts varies in no way with the thickness. You get very little more power out of a thick belt than a

thin belt, unless you run to higher tensions which increases your bearing friction.

Mr. ARMSTRONG: I would like to ask Mr. Wilson if he has made or contemplates making a study of the effect of lubricating oils on belting.

Mr. WILSON: We have not made any tests along that line. Certain of the leather belting manufacturers manufacture so-called oil-proof leather belts, and they are very nearly oil proof. That is, machine oils do not bother them to any great extent, but of course if machine oil gets on any belt it cuts down its capacity to a large extent.

SYMPOSIUM ON MAINTENANCE AND PRESERVATION OF OUR CHEMICAL INDUSTRIES

OUR CHEMICAL INDUSTRIES MADE PERMANENT

By G. W. THOMPSON

Read at the Chicago Meeting, January 15, 1919

During the last four years our chemical industries have had a wonderful opportunity to lay the foundation for a permanent development. This opportunity was occasioned through the cutting off of foreign competition and also through the abnormal demand created by war conditions. This period has passed and we are now on the threshold of another era, an era of readjustment, an era calling for the greatest intelligence and activity of mind if what already has been accomplished is to develop into a permanent industrial gain. To solve the problem of making our chemical industries permanent, it is necessary to study carefully the conditions that are confronting us so that means will be devised for properly meeting them.

There are certain things that can be eliminated from consideration at once. The production of chemical products having practically only war uses must cease. It is to be presumed that no one would advocate the continuation of wars in order that these products should continue to be produced. The proper study should, of course, be made to find out how the chemical products needed for war purposes can be used for peace purposes. It seems improbable, however, that much can be done in this direction. Of course much of the apparatus used in the production of munitions of war can be used in the production of those things needed in peace, and to that extent such industries can be modified and put, as it were, upon a peace basis. It is presumed, also, that in those industries established or developed for purely war purposes, a conservative policy has been followed so that the plants have been more or less paid for from war profits. If this conservative policy has not been followed, I know of no means of preventing financial loss. Such industries should

take their losses and start in again on a new basis manufacturing, if possible, peace products.

Let us consider now the problems that confront the manufacturer of chemical products for which there is a peace demand. We will attempt to list these problems and then proceed to analyze them more fully. As we see it, these problems are: first, how to meet foreign competition; second, how to correct destructive domestic competition; third, how to meet the losses which may result from falling prices should falling prices come as is expected by many; fourth, how to meet the problems of high wages with the probability of their also falling; fifth, how shall our chemical industries more intimately organize for peace production.

FOREIGN COMPETITION

Judging by the expressions of opinion which have so far appeared in the chemical journals, foreign competition presents the most serious problem. The greatest difficulty, however, that arises in considering this problem lies in what we may expect under this heading. There are many diverse views. Some seem to think that Germany will, as soon as possible after peace is declared and the avenues of trade are opened up, commence to dump manufactured chemicals upon the markets of the world. German competition in the past has been considered unfair competition, and it is claimed, without contradiction and perhaps, on the other hand, without sufficient confirmation, that she followed the deliberate practice of selling goods under cost in certain markets until the local concerns supplying those markets were compelled to give up business, and when this result was obtained the price of the German product would be raised higher than the domestic product had been sold for. The Germans would continue to hold the market, as domestic manufacturers would not dare to recommence manufacture with the menace of the unfair German practice still existing as a possibility. The danger of Germany resuming practices of this kind is considered very real by many chemical manufacturers. How real this danger is we have no means of definitely determining.

Before the war international trade was essentially anarchistic; that is to say, each nation controlled, as it thought best, all questions relating to export and import; everything was permissible under international law. Import taxes could be raised or lowered by any

nation as it saw fit. Each nation could lay down its own rules for import admissions. The nearest thing to a general rule which would remove international trade from the anarchistic class were such provisions in treaties in what are known as the most favored nation clauses. These clauses prevented any nation from discriminating against another nation protected by such a treaty in the matter of import or export restrictions.

GERMANY'S ABUSE OF FREEDOM OF TRADE

Under these conditions, as has been stated, everything was permissible, and Germany was best known among the nations of the world for its aggressive abuse of this freedom in international trade. It has been claimed even, that if a manufacturer in another country attempted to follow the same practices as Germany followed, and shipped goods to Germany for the purpose of selling them in the German market at the market price or perhaps below it, he ran the danger that some quickly executed decree would prevent the entry of his goods into Germany, perhaps just at the moment when they had arrived at the German port of entry. An attempt by an individual manufacturer to break down this vicious German practice would, if successful, inure not to his benefit only, but would inure to the benefit of the other manufacturers in his own country and throughout the world. Partly to meet this situation, what was known as the Webb law was passed by our Congress, which permits manufacturers to combine for export business. This law was passed, however, too late to be of much use to American chemical manufacturers, as the war had started. As we are considering the problems now, and not presenting the solution, we will consider the Webb law further on when we are talking of this solution.

The danger of Germany becoming an acute and disturbing factor in international trade is increased by the prospect that Germany will be compelled to incur heavy bonded indebtedness held by foreign nations and their peoples. If Germany should largely become a debtor nation, she can only pay the interest on her debts by an excess of exports over her imports. The heavier the burden laid upon Germany in this respect, the more certain Germany is to become a competitor in the world's markets. Her gold will be drained from her and as soon as that draining has reached its practical limit, the only thing that she can then pay with will be the products of her labor.

As she will need all she can earn to pay her taxes and indemnities and as these will increase her production costs, she may not be able to sell at prices that are menacingly low.

A FUTURE ECONOMIC PROBLEM

Couple with this the fact that during the war the United States has become a creditor nation and its credits and the interest upon them can only be paid, to a certain extent, in gold, of which apparently we have more than is good for us at the present time, and the remainder in merchandise, it can readily be seen that we are in danger of having goods offered to us at relatively low figures, not only by Germany but all other countries; these goods consisting at least to some extent of chemical products.

In order to give a true picture, however, of the situation, we must not neglect to look at the other side. German chemical industries, except for war purposes, have been almost at a standstill for over four years. Many of her plants must have passed into a condition of innocuous desuetude. Each of us knows what it means for a plant to be practically idle for four years. The plant itself deteriorates and the men on whom the successful operation of the plant has depended have become scattered, in many cases have died, and in all other cases, to a certain extent, have lost their art. It is hardly probable that the German chemical industries (speaking now with reference to peace products) are in anything like the good shape in which they were before the war. Furthermore, it seems probable that chemical research along peace lines must have almost ceased in Germany. In this country the reverse of all of this is the case. Our chemical industries have received a tremendous impetus. Men have become trained in chemical operations. Extensive chemical research has been going on in connection with peace manufacture.

GERMANY AN ISHMAELITE

There is another phase of this situation too, that must be considered. Germany has become the Ishmaelite or the pariah of nations. Practically the whole world is wrought up with an intensity of feeling that will prevent the sale of her products if known to be of German origin. Think of this picture as portrayed by James Church Alvord in the *New York Times*:

" By rotting wharves her empty ships shall rock,
Her slattern towns their poverty proclaim,
Her high-towered factories topple block by block
Since ' Made in Germany ' is a brand of shame.
Thrust from the Door of Human Brotherhood,
Misunderstanding and misunderstood,
Beggared, unpardoned, excommunicate—
The Ishmaelite shall wait."

If the picture is a true one, can we really have very much to fear from serious competition with Germany? If true, it indicates that Germany has beggared herself morally and physically, that about the only thing a German can do is to leave his native country, change his name and try to rehabilitate himself in other climes. Mind you, this picture is not one that I am painting, and I do not present it as a picture originating in my mind, but I do present it as a picture that is in the minds of a very large percentage of civilized peoples.

Assuming the very worst as to the dangers of German competition, what is the best method of procedure, utilizing implements at hand for meeting such competition? I offer three practical solutions. The first of these is a combination of the chemical industries for export trade purposes, under the so-called Webb law; second, the formation, in the chemical industries, of what are known as Open Price Associations; and third, the combination of chemical concerns which are not competitive and which are too weak to stand alone—by combining they would be strong.

WEBB LAW

This law, which went into effect April 10, 1918, has for its purpose the granting of permission to domestic manufacturers, sales agents, etc., to combine for the purpose of fixing prices and controlling export trade in the industries in which they are interested. The act starts off to define what is meant by export trade, which means solely trade or commerce in goods, wares, or merchandise exported or in the course of being exported from the United States or any territory thereof to a foreign nation. The act is presumed to relate to trade outside of the United States or any of its possessions, such as Porto Rico, the Philippines, etc. In the act the word "association" is used, which is declared to mean "any corporation or combination, by contract or otherwise, of two or more persons, partner-

ships, or corporations." Evidently it permits a pooling of export profits, which is not permissible in domestic trade to the extent that it interferes with competition. To accomplish its purpose, the act simply declares that previous acts, including the so-called Sherman Law, shall not be construed to apply to associations entered into for the sole purpose of engaging in export trade and actually engaged solely in such trade, provided such association does not "enter into any agreement, understanding, or conspiracy, or do any act which artificially or intentionally affects prices, in the United States, of the commodities of the class exported by the association, or which substantially, in the United States, or otherwise restrains trade therein." It also provides that the act creating a federal trade commission which defines and prohibits unfair methods of competition, shall not be construed as to apply to competition in the export trade. It also calls for the filing with the Federal Trades Commission full details as to the association formed under the act, and penalties for failure to make proper reports. It also gives to the Federal Trade Commission power to initiate prosecution of associations that do not operate within the limitations of the act.

AIM OF THE ACT

This act apparently will permit manufacturers, etc., to form associations that can do practically anything in export trade, so long as its acts do not restrain domestic trade or affect competition therein. It would appear that these associations could do things in export trade that would be considered unfair in domestic trade. Thus if any foreign country attempts to dump its goods on this country for the purpose of injuring domestic trade, the export association could retaliate by selling abroad its products, even at a loss, in order to prevent such dumping.

It is possible, however, that this phase of the act may be subject to the qualifications that the association's export sales are distinctly for the purpose of building up foreign trade and not for the purpose of interfering with domestic competition. However, an act of this kind will have to be interpreted as its practical applications develop. One thing is clear, however, that if associations are formed under this act before foreign goods can be dumped upon this market, and if these associations aggressively seek to develop our export trade in products which might be dumped upon our market, no

criticism could be made, as it could not be shown that they had directly affected competition in this country or restrained domestic trade.

I do not know that I have made my point clear. Let me illustrate it. Suppose there is a certain product which our domestic manufacturers fear may be dumped upon our market. Manufacturers who are engaged in the production of this product can form an export association. If this association is formed in time and endeavors to develop foreign trade in this product before the same product made abroad can be imported, their act cannot be considered in any way illegal. It would also appear that they can continue to offer this product abroad on the same basis of price, etc., even after the foreign made product was offered in this country. If, however, the association was not formed or did not commence to act until the foreign product had already been dumped upon this market, thereby depressing domestic prices, and they should then go into the foreign market for the purpose of preventing such importation, with the result that domestic prices would be increased, the association might be doing an illegal act. I am only attempting to give a common-sense view of this phase of the subject and it may be that my opinion is subject to revision by the mind legally trained. Also it would be manifestly foolish for me to give advice as to what should be attempted under this law in any particular case. Each case should be judged of by itself.

POOLING OF SELLING INTERESTS

The main purpose of the act is undoubtedly to provide for collective bargaining in the export business. By collective bargaining is meant the pooling of selling interests so that those in the pool will not be bidding against each other, thereby depressing prices.

It is interesting to note that a number of associations have already been formed under the Webb Law. Very few associations have so far been formed covering the chemical industries. It is presumed, also, that most of the associations so far formed have been for the purpose of providing collective selling, as in the case of the recent associations covering copper and steel, formed under the names of the Copper Export Association and the North American Steel Products Corporation. No one can tell to what extent the utilization of the Webb Law will assist chemical industries. It certainly

should, however, be studied by our chemical industries, both from the business and legal standpoint, so as to see how profitable use can be made of it. It would appear to be a very efficient instrument for the development of export trade and the meeting of foreign competition.

OPEN PRICE ASSOCIATION

During the last few years a great many of these associations have been organized. Some few of them have been formed covering certain branches of chemical manufacture. Open Price Associations have for their purpose the bringing together of manufacturers of competing products, for the purpose of establishing trade practices and for the general welfare of the trade, to encourage a spirit of good will and mutual confidence among its members and with the trade, to cooperate with each other and with the government authorities to prevent unfair methods of competition and trade abuses, to study and adopt ways and means of eliminating waste in production and distribution, to establish and maintain standards as to quality and to induce truthful branding of products, to study manufacturing costs, devise scientific methods of accounting, and to furnish the members with useful information. All of these things an Open Price Association can do if it determinedly avoids anything like a reduction in competition or attempts to control prices.

Apparently Open Price Associations have met with the approval of the Federal Trades Commission. One of the great evils they seek to correct is what may be described as the sporadic cutting of prices, due to misinformation as to what competitors' prices are. Thus, John Jones hears through the trade that James Smith is after a certain line of business and has quoted very low figures. In a great many cases the information which has come to John Jones is false and is not, under ordinary conditions, subject to verification. He simply has to guess as to what James Smith is doing, and, being fearful that James Smith may beat in the race, he becomes nervous and cuts his price to a figure in which there may be no profit or even a loss. Such a condition is ruinous to business; it serves no good purpose and is in the nature of unfair competition. If, however, there were some system provided whereby John Jones would know in due time exactly what James Smith was quoting, or vice versa, neither of them would be willing to go on record in making ridiculous quotations.

TWO METHODS OF PROCEDURE

This indicates the essential feature of Open Price Associations. To accomplish its purpose two general methods of procedure may be followed. One method is that each member of the association reports to its secretary all sales, the secretary in turn reporting these sales to all of the other members of the association. The other method of procedure is this: If all members published their price lists, they would then report to the secretary only deviations from their price lists, the secretary then advising all the members of such deviations. The second method is one most easily followed with staple products.

Of course it is obvious that no Open Price Association of the kind described can exist unless the members of the Association have a certain degree of confidence in each other. The simple reporting of prices or deviations from price lists will not accomplish much unless the members are honest in their reports. In other words, it is the spirit which develops out of such an organization that is its real value, the spirit of confidence. I presume that in the formation of these organizations, in some cases, the members have come together with the fear and trepidation which Ali Baba felt when he entered the cave of the forty thieves. After an organization of this kind has been in existence for awhile, however, each one begins to be ashamed of himself for having thought so poorly of his competitors and he finds that after all he has no monopoly on honesty and that the other members of the association are not very much better or very much worse than he is. As time goes on he also finds that they are a great deal better than he ever thought it possible for them to be.

RIGHT SPIRIT MUST PREVAIL

The Open Price Association is not a cure-all, and unless entered into with the right spirit it undoubtedly could become a menace. The great temptation for the members of an association is to think that they are gathered together for the purpose of controlling or regulating prices, which of course is illegal. Those that appreciate this danger will studiously avoid any attempt at the control of prices. The association should not eliminate competition; it should not attempt to say what any member shall do with respect to prices. So far as I know, no Open Price Association has as yet been accused

of attempting to regulate prices. Some time such an accusation may be made, but if so, every other association will, for its own safety, more strenuously stay safely within the legal line.

I urge upon the chemical industries the study of this proposition. I believe wherever an Open Price Association is established among chemical manufacturers the result will be better trade conditions, more uniform and more legitimate profits and a greater respect on the part of the consuming public. The cutting of prices below what will give a legitimate profit is not good for the consumer because in the long run what the consumer needs is stability in prices that are sufficiently low. He should not want an unfair advantage in the purchasing of goods, nor should he want a manufacturer to supply him with goods on which a reasonable profit has not been made.

Some Open Price Associations have considered the possibility of using their associations in the furtherance of export business. This is a legitimate development of the Open Price Association, although better conducted in associations formed under the Webb Law. Whatever they may do in this respect, however, it is certain that in Open Price Associations there is an opportunity presented for the discussion of foreign competition. They can act collectively within certain broad limits to cope with this competition. They can conduct an advertising campaign in favor of domestic products. They can furnish each other with information which will enable them to manufacture more cheaply and so be able more easily to meet foreign competition.

COMBINATIONS OF DIVERSE CHEMICAL INTERESTS

The chemical concern that manufactures only one product, or only a few products, is at a great disadvantage as compared to a concern that manufactures a great many products. The uses of chemical products come and go, the demand for them rises and falls, new chemical products are discovered which are continuously displacing those previously manufactured. The profits of a concern manufacturing one product, on being plotted, will show as a rule a very irregular curve. There may be frequent rises and falls; there may be a very rapid rise and then a very rapid fall. I think if any large chemical manufacturing company had the information at hand and could plot its profits with regard to individual products, it would be found that these curves would be very irregular and, on the other

hand, that if they were all combined, other things being equal, there would be shown a more nearly continuous and uniform curve that, with a well-managed concern, would steadily rise.

WIDEN THE BASE OF BUSINESS

I am therefore laying down the rather fundamental proposition that concerns manufacturing chemicals should have as wide a base as possible in order to maintain their stability. I am probably offering nothing new in this suggestion; most chemical companies see the point involved and they have diversified their industries so that loss in one department will be corrected by profits in others. I am wondering if it is not true, however, that during our war period many concerns have gone into the manufacture of specialties without a broad enough base to give them permanence. Is not it possible that there are chemical manufacturing companies in this country that are on too small a base, but which, if combined with some other industry in a similar condition but manufacturing different products, would be able to weather the storm of competition? I am wondering if we have sufficiently learned our lesson from Germany in the diversification of our chemical industries. Are our manufacturing chemical concerns each as inclusive as the German companies in the number of products that they manufacture? Here is a path of progress that I am sure leads to profit.

COMBINES SUGGESTED

It would be foolish, however, for a concern that is manufacturing one or a few products, to think that the only way for him to diversify his industry would be by increasing the number of products. Probably the best thing for it to do would be to combine with some other concern similarly situated but manufacturing other products. As I see it, there is nothing illegal in such a combination, as they were not competing. Of course, to a certain extent, even competing industries can combine, so long as the combination is clearly not one in restraint of trade, and the mere fact that some of the products of one of these companies is manufactured by the other company is no reason in itself why the two companies should not combine, unless by so doing they obtain a monopoly of product. I am not advocating such a combination. The combination I do advocate is only one which will result in the broadening of the base and the diversification

of the industry. In many cases the by-products of one of the companies could be utilized in the manufacturing of the products of the other company, the economy thus resulting being a benefit to both and to the public at large.

If a chemical concern cannot hold its own in domestic competition, how can it hope to meet foreign competition as well? If it rests on a narrow base, how much more likely it will be to topple over in the struggle of foreign competition. By broadening its base it can withstand competition both domestic and foreign.

The danger of our chemical industries being injuriously affected by foreign competition would be very much lessened and in some cases would be entirely removed if our chemical industries made use of the three instruments I have outlined, to wit: Association for export business, under the Webb Law; second, the formation of Open Price Associations; and third, the diversification of industrial operations by such combinations as are possible without destroying competition. Individual initiative would remain intact in the case of all of those instruments and would not involve the asking for Government assistance.

DESTRUCTIVE DOMESTIC COMPETITION

Asserting that the elimination of domestic competition, so far as it is destructive to industry, can only be brought about by combinations which to a greater or less degree restrain trade, there are those who advocate the repeal of the Sherman Law so as to permit combinations in restraint of trade. Personally I am opposed to any advocacy of the repeal of the Sherman Law, primarily because I do not believe that it is a menace or that its repeal is necessary. Particularly is this true with regard to our chemical industries. I have already indicated how, to a certain extent at least, the evils of old fashioned competition can be eliminated by Open Price Associations, and I have also indicated that the real need of our chemical industries is diversification through combinations that are not in restraint of trade. By principal objection to doing away with the Sherman Law, outside of the fact that you could not get it repealed if you wanted to, lies in the proposition that nearly all progress is traceable to competition. If you destroy competition, you destroy individual initiative which is the thing that above all other things should be developed. Forms of organization which appear to be logically

complete but which after all substitute autocratic and bureaucratic methods for individual activity, have in them the seeds of their own destruction.

To meet destructive domestic competition, all I have to suggest is the formation of Open Price Associations and the diversification of industries through combinations that are not in the restraint of trade.

FALLING PRICES

One of the most serious things that appears to confront us to-day is high prices. If we knew that the present prices were to be maintained, that they would not drop back towards what they were before the war, we would have very little concern. We all know that there will be some falling off in prices, because war demands took up such a large supply of goods and labor as to force prices above their natural level. We may, however, be surprised and prices may not go back to their former level. Economists tell us that in general prices, after the Civil War, did not go to the level of what they were before the Civil War, and I venture to express the opinion that not for a very long time, if ever, will prices in general go back to the level they were before this world war. It would lead me too far to go into a discussion of the money question. The quantitative theory of money is pretty well established, and this theory teaches us that prices vary more or less directly with the per capita volume of circulating medium and whatever this circulating medium rests upon. It is probable that the high prices in the United States are directly traceable, to a large extent, to the issue of Government bonds. These Government bonds are in the nature of extensions of credit, and extensions of credit are equivalent to an increase in the circulating medium. Germany has issued large quantities of paper money, and our associates in this great war have to some extent done the same. The Government bonds of our allies and our own country will form a basis of credit which, as I have said, is an increase of the circulating medium. High-priced labor means high prices for goods. If for no other reason, the resistance of labor to a reduction in wages will prevent, at least to some extent, a fall in prices.

For all these reasons I do not believe that the losses due to falling prices are going to be as great as some of us imagine. Of course the conservative business man has already taken care of this possibility to a certain extent, by writing all of his inventories at low figures.

How far he has been allowed to do this by the Treasury Department, I am unable to say, but my understanding is that whether the Treasury Department would allow him to do this or not, in figuring his profits, it has allowed him to create such reserves as may be necessary to meet this condition. If reserves have not been created and profits have been divided on full war earnings, he is apt to be in a bad way and I know of no means of saving him without what would correspond to a surgical operation. If possible, reserves should be created in order to meet the possibility of lower prices.

HIGH WAGES

As I have already indicated, I do not feel that prices will fall very much or that wages will be very much lower. I am not considering here that we would want to do or what labor leaders want to do; I am only presenting my own diagnosis of the situation. If, however, wages do tend to go down, there will be something of a corresponding fall in prices. Each employer will have to consider the extent to which it is profitable to him to reduce his employees' wages. He has very little arbitrary power in this matter, but he can exercise a considerable amount of intelligence, and I personally believe that high-priced labor is more profitable than so-called cheap labor, although I do not mean by that that if you increase an employee's wages you thereby immediately increase his efficiency to a greater extent. I notice, however, that the men who are getting the highest wages usually get them because they are worth more than those who are getting less.

There will be a feeling of duty on the part of every employer of labor to take back those employees who have been in the Government service, finding positions for them as best they may. Many of these men who have served in the army and navy will come back with increased efficiency, unless indeed that efficiency is interfered with by injuries received. They will have a new view of life; they will be more democratic in their valuation of men than they were before. I am inclined to think that the men and women who have been in the service will have ideas that the intelligent employer cannot ignore. They will have become a political force of no small magnitude. Many of them have been fed by Uncle Sam better than they were ever fed before. In general their standards of living will have risen. The intelligent employer will not see his way clear arbi-

trarily to reduce wages. In view of these facts, the unintelligent employer, if he attempts to exercise his arbitrary power, will be confronted by strikes, without the support of public sentiment.

I do not know how to meet this problem of the wages of labor, except through a broad sympathetic spirit that says: "I may have to reduce wages and if I have to I suppose I shall, but as long as it is in my power not to do so, I will not do it."

I make this suggestion simply as a business proposition. There are enough things confronting us to disturb business conditions and we should not seek for other forms of trouble. Undoubtedly there have been a great many employees discharged, with more to follow. There will be a large number of possible employees released from the army. There will be a freer labor market. But many of our industries have been very short of labor for a long time and this shortage has not been met as yet. There may be no surplus of labor. The demands of the world for labor's products show no abatement. With peace production so much curtailed and with the awful destructions of wealth during the last four years, it would appear that the demand for industrial products would be great for some years to come.

ORGANIZATION OF CHEMICAL INDUSTRIES

I have already indicated how, under the Webb Law and through Open Price Associations, our chemical industries can become more highly organized. There is little I have to suggest beyond this. I have only this thought to add. I know of no industry that is so continuously changing as the chemical industry. It cannot stand still. It must either go forward or backward. To go forward there must be cooperation between our industries and our educational institutions, there must be more chemical research and more active drafting of men of technical education into the commercial world.

In conclusion let me add this further suggestion. Opportunities very seldom come knocking at our door. They are usually met in the course of our search for definite things. The recognition of opportunity when one meets it is a measure of intelligence. Particularly is this true in chemical industries. Opportunity presents itself in the unexpected discovery of new products and in the unexpected discovery of new uses for relatively old products. Very often opportunity appears at first in the disguise of failure. In general the success of any business, or we might say everything,

depends upon its opportunities, but it also depends upon their utilization.

What the future holds in store for us is largely a matter of opinion and my opinion makes me an optimist. I am optimistic as to the opportunities that lie before our chemical industries. I am optimistic that our chemical industries are managed by men of so high intelligence that the opportunities that lie before them will not be overlooked. The world is in a state of flux requiring the greatest agility of mind if legitimate profits are to be extracted. This agility of mind I believe we possess. The future can only determine whether I am right or wrong.

RÉSUMÉ OF CONDITIONS AS THEY EXIST AT PRESENT IN THE CHEMICAL INDUSTRIES

By MAXIMILIAN TOCH

Read at the Chicago Meeting, January 15, 1919

We are facing such extraordinary and unique conditions in the chemical industry, brought about by the great War and by its sudden cessation, that this symposium, if acted upon by our legislators, will do much to foster the industry, or cripple it, depending entirely upon reasonably quick and intelligent action. In the words of Kipling, it will soon be decided whether we are

"Brother to a prince or fellow to a beggar if we be found worthy."

In opening this symposium, I do not wish to speak for the Committee of which I am the Chairman, but I prefer to utter my own sentiments, so that my confrères shall not be embarrassed should I utter a sentiment with which they do not agree. At the same time, I propose simply to outline the condition as it exists.

The well-known English author, W. H. Wells, as you may remember, wrote volumes in the American periodicals in the first years of the War, in which he forecast the outcome of the War in the near and distant future. I think Mr. Wells was in that mental attitude, because in 1913 he had predicted the invasion of Belgium and the Battle of the Marne, but he went so far in his prognostications, most of which were unjustified by subsequent events, that he finally said about a year ago "He who prophesies much is likely to hit it right occasionally," and that is about my condition if I should attempt to prophesy; but I am not going to make any rash forecasts, but place the facts before you and let those who have been invited here to discuss the maintenance and preservation of the American Chemical Industries give their opinion; and ultimately, their advice.

It is by no means positive that a very high tariff protection is going to be the panacea that will remedy all evils, although it is a

fact, and at the present time a historical fact, that industries like the steel, tin plate, cutlery and lead industries in the United States only became the great industries that they are after a protective tariff had fostered them in their infancy. Of course, there is the economic difference between European countries and ourselves. I need only point out to you that the Liberty Loans of the United States in one year were equal to the entire loans of Germany for four years and that the United States Government's expenses covered the wants of 2,000,000 men and that of Germany of more than 10,000,000 men. This is due entirely to economic differences. The pay of the soldiers in Germany was relatively less. The pay of the workmen in the munition factories and the cost of materials were far less than in America. Before the War, Azo Scarlet Dye cost, landed in America, between fifteen and twenty cents a pound. It costs to manufacture to-day eighty-five cents a pound, and this will possibly be brought down to sixty-five cents, if raw materials, and possibly labor, will cost less for the next year. But, assuming that everything is double in Germany and Switzerland, or even assuming that things have gone up one and a half times their pre-war prices, which I think is doubtful, Azo Scarlet Dye could be landed in this country at considerably less than our cost of manufacture. So, it will be necessary to have a protective tariff in the first place.

A condition has arisen which must be met squarely, and it is not a condition that is going to right itself by any means. We have committed ourselves altruistically to furnish the nations of Europe, particularly the Allies, 20,000,000 tons of food stuffs, and it is estimated that it is going to take considerably more than a year to forward these supplies. Cargo space is naturally very limited and excessively high in price owing to these conditions. Heavy chemicals, which are worth anywhere from \$20 to \$80 a ton, cost \$100 to \$150 a ton for freight and insurance alone, so that export is practically prohibitive. On the other hand, after this vast tonnage of food stuffs and building material arrives in Europe, the ships, instead of coming back empty, can bring back materials in competition to us at a far lower freight rate than we can obtain for export, and that is a condition which must be squarely met.

Another condition which confronts us is the hardship produced by the Sherman Law, which prevents any formation of trusts or any cooperation among manufacturers in this country. On the other hand, we have now the Webb Act, which permits the fixation of prices

of chemical products for export. If a condition should arise which will glut this market with large quantities of chemicals, manufacturers will cut prices to such an extent that ruinous competition will take place, and some provision should be made which will permit manufacturers to cooperate with each other rather than bring about ruinous price cutting, which the Federal Trade Commission will be forced to straighten out. It is a case of prevention rather than cure.

Anybody who imagines that Germany is commercially dead is laboring under a very great misapprehension. We have seen, even since the armistice, the wailing cry that has gone up for food and freight cars, which has been unwarranted.

President Wilson in his reply of October 23d to the note of the German Government dated October 14th, said:

“The nations of the world do not and can not trust the word of those who have hitherto been the masters of Germany policy.”

In the address of President Wilson delivered before Congress on January 8, 1918, now known as the famous Fourteen Points, which constituted the programme of the United States, because they constituted the programme of the World's Peace, the Third Point is of vital significance to the manufacturing interests in the United States, and reads as follows:

“The removal, so far as possible, of all economic barriers and the establishment of an equality of trade conditions among all the nations consenting to the peace and associating themselves for its maintenance.”

I doubt very much whether the real interpretation of this Point has been made, and if the President meant that there should be free trade among the League of Nations, it will cause a hardship to those who pay the highest wage, and also to those countries, coincidentally, where freight and the cost of raw materials is higher than in other countries. A fair example of this would be the cost of mining and transportation in those European countries where labor receives ten cents an hour in our money and where we pay forty cents an hour. The question of a protective tariff, or a tariff for revenue only, will never be solved. Conditions vary to such an extent that you cannot base these on any mathematical unit of measure, and the lawmakers of each country will from time to time have to treat each case specifically. You will recall in the McKinley Tariff, when two ques-

tions came up for the protection of infant industries. One was the manufacture of tin plate in this country and the other the manufacture of high grade cutlery. In each case a specific tariff had to be enacted on account of the relative economic difference between those countries in Europe where these materials were made, and our own country; and the protective tariffs, which were considerably more than a tariff for revenue, fostered these industries, so that to-day they are established beyond peradventure. I need not cite any other cases, as these two examples are sufficient, although there are many more.

So, summing up the condition of affairs as it exists to-day, we are manufacturing pharmaceuticals, photographic chemicals, barium chemicals, dyes and the intermediates from which they are made, and pigments, and I am reliably informed that over 2,000,000 men and women are employed in the United States in these newer industries, directly and indirectly, and I am sure that it is the policy of our Government not to disrupt and not to destroy the wonderful and remarkable enterprises which we have established; for, looking the facts squarely in the face, the Captains of Industry who have provided the money and the installations for these new enterprises have been altruists in the fullest sense, and they should not be penalized for their altruism—quite the opposite, they should be encouraged.

Briefly stated, the suggestions which should be presented are:

First.—A reasonable tariff.

Second.—An amendment of the Sherman Act so that we may have permission for competitors to cooperate, and this Act should be so construed that the conclusions arrived at by competitors shall be submitted to a proper tribunal for its consent.

Third.—A law, or ruling, which shall be effective without going before Congress, so that in case a foreign country ships materials into this country at or below cost in restraint of American trade, such materials will be held in bond until a proper investigation be made in order to prevent disruption of American trade.

Fourth.—The source of origin of every material, raw or manufactured, must be stated by the foreign shipper under oath. This is to prevent a neutral country acting as agent for an enemy country.

Fifth.—No combinations in restraint of trade should be permitted by foreign countries against the United States, and wherever a foreign competitor sells goods at below the cost of American manufacture, their importation shall be prohibited.

RECOMMENDATIONS OF THE TARIFF COMMISSION IN REGARD TO DYES AND COAL-TAR CHEMICALS

By GRINNELL JONES, Chemist of the U. S. Tariff Commission

Read at the Chicago Meeting, January 15, 1919

The United States Tariff Commission has recently sent a Report to Congress making recommendations for amendments to the present tariff law on Dyes and other Coal-tar Chemicals. It is believed that this report will be of interest to many not directly connected with the new dye industry, because it illustrates the character of work which the Commission can do in helping to solve the problems of reconstruction.

Before discussing in detail the more important of the amendments recommended to Congress, it may be well to explain briefly the limitations under which the Commission is working. These limitations are in part the restricted legal powers of the Commission, and in part questions of expediency.

In the first place, it should be made clear that the law creating the Commission and defining its duties does not confer upon it the power to settle broad questions of tariff policy. The issues of high or low protection, tariff for revenue only, or free trade, will, and should, remain questions to be settled by the people. The application of whatever general principle is adopted at the polls must be made by Congress. The function of the Tariff Commission is to collect, systematically, for each commodity, facts likely to be helpful to Congress in determining for each commodity the rate which best expresses its fundamental purpose, and the language which will describe each article in words least likely to result in uncertainty and litigation.

The information which may be regarded as pertinent for tariff purposes takes an extraordinary range. It includes the specifications of the various grades or varieties of each article which appear in commerce, and the names or synonyms in commercial or scientific use. Processes of manufacture must be studied in sufficient detail to make clear the raw materials used, the economic characteristics

of the industry, any differences in American and foreign methods, and any natural advantage or disadvantage of the industry in the United States as compared with foreign rivals. Statistics showing the volume and paths of international trade in each article must be compiled and interpreted and compared with the volume of production at the chief sources. The influence on international trade of American and foreign import and export duties, reciprocity treaties, and colonial preferences must be studied. Although the Commission does not regard the tariff as primarily a local issue, the geographic distribution of each industry within the United States is, nevertheless, of interest. The revenue to be expected from each item must be approximated. A careful study must be made of all litigation under the tariff laws in order that ambiguities may be avoided in the language of future tariff laws. The uses of each article must be considered with reference to other industries likely to be influenced by any change in duty. Finally, it should not be forgotten that, according to one theory of the tariff, the most important factor in determining the proper rates is a comparison of domestic and foreign costs of production.

Briefly the Commission's duties are primarily to collect facts and to present them in a convenient form. It has ample legal powers of investigation, at least in the United States, but inadequate appropriations to carry out its work. It has no power to recommend rates of duty. It can however point out the industrial effects of the present duties or of abnormal relationships between rates on raw materials and finished products or on competing products.

The recommendations which the Commission makes in regard to Dyes and Coal-tar Chemicals are therefore concerned primarily with the language or technique of the tariff law.

Owing to the political situation it seems unlikely that there can be any general tariff revision until after the next Presidential election. If anything is to be done in advance of that time to meet the special needs of the new Dye Industry, the revision must be presented in such a way as to avoid serious controversy. Any radically new policy, especially any proposal which would arouse the opposition of consumers or antagonize either political party has little if any prospect of enactment into law until after the next Presidential election.

The work undertaken by the Tariff Commission on Dyes and Coal-tar Chemicals may be divided into two parts: First, a study

of the growth of the industry in the United States, chiefly by means of a detailed questionnaire, which includes an annual census of production. Such a census was taken in 1917 and was published last September in a pamphlet entitled, "Census of Dyes and Coal-Tar Chemicals, 1917." A similar census for 1918 is being taken. Second, a careful study of the tariff law and its practical operation. The report which has just been sent to Congress deals primarily with this question, and contains definite recommendations for amendments to the present law.

You will recall that on September 8, 1916, at the earnest request of consumers of dyes, Congress passed a bill raising the duty on dyes and other coal-tar chemicals. The passage of this bill doubtless encouraged the investment of capital in the industry, and thus accomplished, in part at least, the purpose of Congress. It has, however, become clear that the law is not so worded as to give effect fully and completely to the presumable intent of Congress. There are many possibilities of evasion of duty by chemical tricks, as well as legal loopholes, through the failure of the Act of September 8, 1916, to repeal all of the provisions of previous laws which were in conflict therewith. In the bill which the Tariff Commission has sent to Congress, the attempt is made to prevent such evasions. Although most of the forty-five amendments proposed are intended to give full legal effect to the original policy as expressed in the present law, a few of them raise new questions of policy.

I shall now pass on to a discussion of a few of the more important amendments. You will recall that the law classifies coal-tar products into three groups. Group I includes the crudes which are on the free list, Group II contains the intermediates which are dutiable at 15% and 2½ cents per pound, and Group III includes the finished products, most of which are dutiable at 30% plus 5 cents per pound.

Seven amendments are proposed to Group I, but I can take time to refer briefly to only one of them. In the present law, cresol is placed on the free list, whereas phenol, although found naturally in coal-tar and made from coal-tar commercially, is placed on the dutiable list. The distinction was presumably made because of the military importance of protecting the synthetic phenol industry. As a further safeguard for the synthetic phenol industry there is also a provision intended to prevent the duty free importation of mixtures from which phenol could readily be recovered. The provision referred to imposes a duty on "all distillates which on being subjected to dis-

tillation yield in the portion distilling below 200° C. a quantity of tar acids equal to or more than 5% of the original distillate."

Complaints and litigation ensued when this provision was put into effect because under it, many samples of commercial cresol were declared dutiable in spite of the provision for cresol on the free list. A careful study of the provision, made with the cooperation of Dr. Pickrell of the Appraisers Laboratory of New York, leads to the conclusion that 200° C. is an unsuitable choice of the temperature to be used in the analytical distillation, as that temperature is above the boiling-point of orthocresol. Many specimens of true cresol not containing more than a small percentage of phenol nevertheless yield more than 5% of tar acids when distilled at 200° owing to the distillation of orthocresol. The remedy proposed is to lower the temperature for the analytical distillation to 190° . Through the cooperation of Dr. Pickrell nearly 100 samples of actual imports were analyzed, both by the method now specified in the law and by the proposed method, and the results clearly demonstrate the superiority of the proposed method.

Twelve amendments are proposed which affect Group II—the intermediates. The present law mentions a long list of intermediates by name and adds a provision for "all similar products." The list contains no intermediates used primarily for making medicinals, and some important types of chemicals are not represented. Whether such intermediates would be held by a court to be similar to any of those mentioned is questionable. It is proposed that 35 additional intermediates be mentioned by name in order to remove any possible doubt as to whether they are "similar," and to ensure the collection of detailed import statistics. The provision for "all similar products" is replaced by a provision for "all other products" which are obtained from coal-tar and used for making dyes and other finished products, but which are not themselves dutiable under Group III.

Several substances appear in commerce in two grades: a U. S. P. grade used in medicine and a technical grade used as an intermediate in making dyes. Benzaldehyde may be cited as an example of this double use. It is suggested that the U. S. P. grade be made dutiable under Group III at a higher rate, as a finished product, and that the technical grade remain in Group II as at present.

Under the present law, it is possible for mixtures of intermediates to be classified under the old law of 1913 at a lower rate. This method of evading the duty is prevented in the new bill.

It is in Group III, however, that the most important changes appear. Many of the amendments are proposed for the purpose of preventing evasion of the apparent intent of Congress in passing the Act of 1916. For example the tariff Act of 1913 imposes a duty of 25% on salol. The Act of 1916 imposes a duty of 30% on "medicinals, . . . when obtained, derived, or manufactured in whole or in part" from coal-tar, but fails to repeal the provision for salol in the Act of 1913. It is a settled principle of tariff law that if an article is covered by two provisions, effect is to be given to the provision which is the more specific. Although it is apparent that Congress intended to make medicinals dutiable at a higher rate, the failure to repeal the more specific provisions in the older law has resulted in actual practice in the assessment of the lower rates according to the old law. This case and many others like it have been remedied in the bill proposed.

Another possibility of evasion arises from the circumstance that certain commodities classed as intermediates, which in the Act of 1916 are in Group II, and are subject to a duty of 15% ad valorem and 2½ cents a pound, are transformable into finished products at very slight expense and by very simple processes. There are, for example, certain intermediates called leuco acids and leuco bases (i.e., colorless compounds), which are not strictly dyes, yet have been carried in the process of manufacture to a point where only an insignificant and inexpensive operation is needed to convert them into dyes. Under the Act of 1916 they will inevitably be imported in the leuco state—not quite finished as dyes, but very nearly finished; they will subsequently be converted into dyes in this country, cheaply and easily. They will be imported at the intermediate duty of 15% plus 2½ cents, and will compete directly with completed dyes of domestic manufacture. A striking instance is that of indoxyl, an intermediate which is in the last stage in the succession of processes by which synthetic indigo is obtained. Indoxyl is a colorless substance, not a dye, but by the mere process of dissolving it in water and blowing air (oxygen) through it, the last chemical step in the production of synthetic indigo is completed, and the commercial indigo is produced. Indoxyl is dutiable under the present law as an intermediate; indigo is dutiable as a dye. It is more than probable that, under the terms of the present law, importation will take the form of indoxyl; and this will be virtually the importation of indigo, competing with indigo of domestic manufacture. It is therefore

recommended that indoxyl and leuco-compounds be made dutiable at the same rate as dyes.

In the manufacture of many dyes, the necessary intermediates are heated or melted with suitable inorganic reagents such as sodium sulphide, caustic soda, or zinc chloride, and the chemical reactions thereby produced result in a dye or a substance so nearly approaching a dye that it can be converted into a dye by very simple and easy means. Although such crude melts have not been imported in the past, they probably could be imported in some cases under the present law at a lower rate of duty than dyes, and the manufacture completed here. It has been difficult to find legal phrasing which would be effective in preventing such evasions, but it is hoped that the problem has been successfully solved.

Other forms of evasion for which remedies have been proposed include the importation of dyes as "ink powders" at 15% and the importation of artificial methyl salicylate as oil of wintergreen.

The Commission takes the view that when Congress levied a duty of 5 cents per pound on dyes, it intended the duty to apply to the usual commercial strength of dyes, and that the practice of importing dyes in a more concentrated form, and diluting to the usual commercial strength after passing the custom house is an evasion of the intent of Congress. The Commission recommends legislation which is intended and expected to stop this practice and which will make it easier for the appraisers to prevent undervaluations. This involves a standardization of dyes under the direction of the Secretary of the Treasury with a provision that the 5 cents per pound duty shall be levied on the basis of these standards. There is a further provision modeled on the misbranding clause of the Pure Food and Drugs Act that all imports shall be truthfully labelled in such a way as to show the identity and strength of the dyes. This provision will prevent the importation of German dyes under Swiss names.

Under the present law the 5 cents per pound specific duty is not imposed on many important dyes such as indigo and indigoids, alizarin and the vat dyes for cotton derived from anthracene and carbazol, nor on medicinals and flavors. The Commission recommends that the specific duty of 5 cents per pound shall be levied on all dyes, medicinals and flavors.

The present law contains a provision for "synthetic phenolic resin," which was evidently intended to cover such articles as Bakelite, Condensite, and Redmanol. This phrase presented one of the

most perplexing problems in the entire bill, because it is not adequately descriptive and may be interpreted in a way which is unduly restrictive. The articles referred to are not identical with the true natural resins, such as amber, kauri or rosin, and it is therefore questionable whether they are properly described as "synthetic resin." Moreover the term "phenolic" is unduly restrictive, since there are products not made from phenol which are similar to, and compete with, the products made from phenol.

It is a general principle that goods should be described in the tariff law in the language ordinarily used in commerce, but in this case this principle can not be applied because trade names are in almost universal use. After much correspondence with all the manufacturers and others familiar with these products, the Commission invited each manufacturer to send a representative to a general conference where there was a three-hour discussion of the whole problem. The amendment which is suggested as a result of this conference, although not free from objection, is believed to be a great improvement over the phrasing in the present law. The amendment proposed is as follows:

"In place of 'synthetic phenolic resin,' substitute the following: 'synthetic phenolic resin and all resin-like products prepared from phenol, cresol, phthalic anhydride, coumaron, indene, or from any other article or material provided for in Groups I or II, all of these products whether in a solid, semi-solid, or liquid condition.'"

In the hope of encouraging the growth of a new infant industry in the United States, the Commission also recommended that synthetic tanning materials be added to Group III at 30% plus 5 cents per pound.

You will recall that specific duties of $2\frac{1}{2}$ cents per pound on intermediates and 5 cents per pound on finished products are referred to as special duties, and that the present law contains a provision which reads:

"If, at the expiration of five years from the date of the passage of this Act, the President finds that there is not being manufactured or produced within the United States as much as sixty per centum in value of the domestic consumption of the articles mentioned in Groups II and III of Section 500, he shall, by proclamation, so declare, whereupon the special duties imposed by this section on such articles shall no longer be assessed, levied, or collected."

The Commission points out serious difficulties in the adminis-

tration of this provision and recommends that this clause be repealed.

The next report to be issued by the Commission on chemical subjects will deal with a group of acids covered by paragraph I of the tariff act including boric, formic, oxalic, lactic, citric, tartaric, tannic, gallic and pyrogalllic acids. This report will discuss the competitive conditions in these industries. A similar report dealing with the Heavy Chemicals is also under preparation, but not so far advanced, and the ground work is being laid for still other reports. The Commission will welcome the cooperation of the members of the American Institute of Chemical Engineers in giving information and suggestions which will be helpful in the preparation of these reports.

ADDRESS AT DINNER, JANUARY 16, 1919

Dr. JONES: Mr. Chairman and Ladies and Gentlemen: I know it is a social blunder to try to be serious at a banquet but unfortunately I am so constituted that I can't tell a story in such a way as to make it seem funny. I wish however to take this opportunity to express my thanks for the appreciative language in the resolution which was passed by the Institute this morning in regard to my labors. However, I am sure knocks are better for my soul than appreciation, and therefore I am very sorry that a previous appointment on other official duties made it impossible for me to be here this morning to hear Mr. Hilton's discussion of the report which the Tariff Commission recently issued in regard to Dyes. I understand though from the remarks which he and others have made to me that Mr. Hilton expressed disappointment that that report did not go far enough. I want first to try to explain that situation very briefly.

There have been a great many proposals brought to our attention in the way of legislative assistance to the new American dye industry, and I want briefly to analyze those. But first I want to say that I think the legislative assistance will contribute very little toward saving the industry in comparison with the work of our chemical engineers and the trained organic research men. In the meantime perhaps some help can be given in a legislative way to allow the chemical engineers time to tackle the job properly.

The proposals to help the industry may be divided roughly into

four main classes. We have proposals for an effective anti-dumping legislation, we have proposals for some sort of a licensing arrangement, a continuation of the wartime import and export licenses, and there are proposals for increases in rates of duty, and finally proposals for the perfection of the language of the law so as to make it really effective. Those four classes, I think, constitute the more important different lines of attack on that problem.

The report which we have just issued and which Mr. Hilton does not think goes far enough concerned the last of those four classes. That does not necessarily mean that the Commission is opposed to or is not considering the other lines of endeavor, and other lines of attack of the problem, and I want very briefly to touch on those others in just a few words.

First, in regard to the anti-dumping question. The Commission is very much interested in that phase of the subject. The Commission has done a great deal of work trying to study it. They have sent their best investigator up to Canada to study the Canadian anti-dumping law. They have sent out many hundreds of letters, had scores of interviews with American manufacturers. What they are trying to do first is to get definite, specific, detailed information in regard to individual cases, as full and complete details as possible, in order that they may be studied with the point of view of the trade to devise an effective remedy. Although I have not followed the details of that at all as I have had no direct connection with it, yet when chemical questions came up they were referred to me and I get the general impression that they have had difficulty in finding very many cases in which they can get definite, precise detailed information.

Then passing on to the other aspects of it, the question of increased rates, the proper rate depends, of course, primarily on what is going to happen in Germany in the next six months and the next five years, and anybody who thinks he knows about it has got a good opinion of himself. It seems to be one of the most difficult things to predict, and until you do know something about that the question of the proper rate of duty is extraordinarily difficult to handle, and in the bill which the Commission has recently sent to Congress no pretense, no attempt was made to touch that question at all. The Commission however is doing the best it can to be prepared to meet that situation. That calls for an attempt to know what is going on abroad as soon as possible. We were fortunate in that one

of the young men trained in our office and who is familiar with the type of information we need is over in France now. We could not keep him out of a uniform last summer when things got pretty hot, and he is abroad, but we made arrangements to have him given a leave of absence from the army and he has some very detailed letters of instruction as to specific things he is to endeavor to find out. Fortunately we were able to effect a cooperative arrangement with the Department of Commerce. The Department of Commerce is interested in the same problems from a different point of view slightly, but nevertheless interested very much in the same problems. The Department of Commerce has arranged to send two investigators abroad to study the situation there. One, Mr. Henry Wigglesworth, Vice-president of the General Chemical Company and Director of the National Aniline Company, will go as a representative of the Department of Commerce officially, with all the official letters of introduction and the confidential relations that can be established in that way. He will be accompanied also by Mr. C. B. Snow of the Department of Commerce who is a very able and capable man.

Then a few words on the licensing question. I am unauthorized to make any statement as to what the attitude of the Commission is likely to be on that, in fact, they have not determined themselves, I am sure. The proposal is briefly that there shall be some arrangement to continue in some form or other the present scheme, or perhaps I should say the wartime scheme, of requiring a specific license for each individual importation or exportation of goods; in other words, some arrangement by which no dyes shall be imported without a special license from some Governmental bureau, the theory being that this license shall not be issued unless the importer can show that that particular dye is not being made in the United States or being made in sufficient quantities to supply the demands, and that it is necessary for the American textile industry. Now as I say, I am entirely unauthorized to express any opinion on that for the Commission. They are studying it carefully, but they have not reached any conclusion on it, but I won't dodge the issue and hide behind somebody else on the matter. I will say frankly, although I have studied it sympathetically, it does not seem to me a practical scheme. There are too many complications, too much trouble. There are too many people who would be injured by it and it is an autocratic way. You have to say to this particular importer, "No, you shall

not import this particular dye. You may think you need it but you don't need it. You can get something else." It involves a host of other complications. Suppose you say to the American textile men, "You shall not import this particular dye." They may say, "Well, if you won't let us import that dye you ought not to let the cloth with that dye in it be imported" and our custom officers then would have to examine every necktie that might possibly contain that dye to determine whether we should bar it from this country. Furthermore, this question is far broader than the mere dyestuffs question. If a thing of that sort is going to be done I think there is no chance that it will go through for dyes alone. If Congress is going to pass such a bill it will have to apply to a great variety of commodities. So it did not have a proper place in the bill which I have recently prepared and which the Commission sent to Congress. It is far broader than the dye question. Similarly any anti-dumping legislation must apply to the whole field of manufactured articles. Therefore it had no proper place in that particular bill. All that I was instructed to do in the preparation of that bill was to try to fix up the technique of the bill, the language of it, the phraseology so as to make it legally effective, so as actually to accomplish in law what was the evident purpose and intent to accomplish. That I have attempted to do and I have received a great deal of help from many men in the industry. It has been my chief task for the last year and a half. I devoted more time to it than any other one thing, and I have consulted a great many specialists in the field and gotten a great many helpful suggestions. I want in particular to acknowledge my indebtedness to one man, Dr. E. R. Pickrell, Chief Chemist of the Board of Appraisers at the port of New York. Dr. Pickrell has for a good many years now been responsible for examining the goods as they came in, passing on them and determining what they are. He has acted as expert witness for the Government in a great many tariff cases, rate questions arising out of the tariff laws. The best job I did in connection with the whole business was to establish friendly and cordial relations with Dr. Pickrell and to get him to give me the benefit of his experience in that field and he has done so without stint. It has been tremendously helpful and a great many ideas that are contained in there owe their origin to Dr. Pickrell. I thank you (applause).

THE MAINTENANCE AND PRESERVATION OF OUR DYESTUFF INDUSTRIES

By ROBERT HILTON

Read at the Chicago Meeting, January 15, 1919

So much has already been written about the preservation of our Chemical Industries that I doubt if I can add anything new: But there are certain phases of the situation that may bear emphasis. As my interest and experience lie directly in the Dyestuff Industry I will confine my remarks to this branch of chemical manufacture.

I take it that we all agree on the premise that the dyestuff industry in the United States must be conserved at all cost. We are familiar with Germany's attitude towards the establishment and growth of the dyestuff industry outside of Germany. We know something about her post-war plans, her combination, for a period of 50 years, of all her dyestuff industries and her determination to dominate the world markets. We recognize the immense advantages Germany enjoys as the result of her forty years of activity in this field. We sense deeply the Prussian spirit which will do everything and anything, regardless of morality, to bring about the ends she seeks and we know that Germany will not meekly give up without a great fight an industry that has netted her millions of dollars every year.

How are we to meet this situation? we who are rooted to the individualistic idea in industry and our laws forbidding combinations while our German competitors are compelled to operate as a unit. If the dyestuff industry were a much less complicated one, involving few products and a limited capital, we would not be at this great disadvantage. The dyestuff industry is of such a nature that I doubt if a number of individual manufacturers without a sanctioned governmental agreement as to prices, output, etc., could exist in the long run and build up a great industry.

In my opinion outside help is therefore necessary and this help can come only from our government.

The first necessary step would be to shut out the German products by high tariff and by the system of licensing advocated by Great Britain.

The framing of adequate tariff legislation has proven to be so difficult, owing to the divers and complicated processes of dye manufacture, that Great Britain has about given up this idea and has concentrated its efforts on a licensing system which would shut out the importation of all such dyes that are made in Great Britain, but would allow the importation of dyes not made at home and those of which an insufficient amount is produced. Furthermore Great Britain, through its Board of Trade, intends to make considerable loans at favorable rates for the building up of the industry.

Let us consider for a moment what has been done here in the States to help our industry. The recent slight tariff increase on dyes brought about by a Democratic administration in itself is noteworthy and commendable, but it will in no way help the industry because it is absolutely inadequate, especially so if undervaluation for tariff purposes is allowed to go on as it has in the past. An increase in the tariff rate, unless it be so high as to amount to prohibition, will do but little good. In my opinion the example set by Great Britain is the one to follow and every effort should be made to have Congress recognize the soundness of the licensing principle.

Prof. Taussig, in his talk before the Dyestuff Manufacturer's Association, warned the manufacturers not to place before Congress any radical measures, such as the Licensing System may be considered, for fear that such proposals would not be received with favor. With all deference to Prof. Taussig, it seems to me that the dyestuff situation here in the States is in a precarious condition and radical methods must be adopted to save a key and pivotal industry necessary to the welfare of the nation, an industry in which over \$100,000,000 has been invested and which indirectly controls the labor of over 2,000,000 men.

A negative attitude on the part of the Tariff Commission for fear that a necessary radical measure may not carry does not inspire confidence and tends to bring about defeat. The licensing system, in the minds of some of our best thinkers, gives greater promise than any form of tariff legislation and besides this we have Great Britain's example. May we not therefore suggest to our Tariff Commission a more positive stand and advocate a radical measure where a radical measure is absolutely necessary. Congressmen are human

and are actuated by good impulses of a positive nature, but a wavering, fearsome and negative attitude will never bring results. The suspension, or at least the modification, of the Sherman Anti-Trust Law, allowing trade agreements and the fixing of prices under government control, would do much to stabilize the industry. It is hard to reconcile the fact that products made under Trust or Kartel control are allowed to be sold in competition with products manufactured in the United States when our laws prohibit Trusts and Kartels. If Congress would pass a law prohibiting the importation of articles manufactured under Trust control it would do much to place our dye industry on a firm basis. To my mind this suggestion has not been exploited enough, commensurate with its obvious importance to industry.

If Congress in its wisdom should decide to put up the necessary barriers to the importation of dyestuffs, it should still further protect the industry by prohibiting German firms from engaging in the manufacture of dyestuffs here in the United States, and assume the same attitude that Germany has taken in her own courts in not allowing any industry to thrive there which may work counter to her national welfare.

The fear has been expressed that if the United States would put up a tariff wall against Germany, Germany would discriminate against us in the matter of potash, the monopoly of which she has enjoyed for many years. France, since her acquisition of Alsace-Lorraine, is now in a position to supply us with all the potash we may want at favorable rates and the German potash monopoly no longer exists. In this respect the restitution of Alsace to France concerned deeply all the Allies and not France alone.

It has been said that science knows no frontiers. This would be true as an absolute proposition, leaving contingencies out of account, and it would have been true if the lust of military autocracy, of conquest, and of the absorption and subjection of other nations had not made of science an instrument of abuse, of despotism, and of violence in the hands of a predatory race. The Central Empires have naturally distorted the spirit and the mission of true science, the mother of progress. Under the name of "Kultur" they have associated it with unbridled barbarism, making it an accomplice of the worst excesses.

To the true American there must be a complete severance from Germany in all relations and we must look to our government to

bring this about, not only as punishment for their hideous crimes, but as a mark of respect and honor to the men who have given up their lives to the cause of freedom.

If the dye industry in the United States, through the help of the government, may develop itself to the extent that fair profits would result, the means would be at hand for scientific research, the value of which we as chemists fully recognize in the upbuilding of any industry. The American chemist will put the same pep into research that the manufacturers have put into their methods of production, but we must first be assured of the necessary profits to furnish the means for the cost of research work.

The Webb-Pomerene Bill will undoubtedly do much to help our export trade. An extension of the provisions of this bill, allowing collective buying as well as collective selling, may be of great help to certain chemical industries.

The revision of our Patent Laws should be taken up at once so that the practice of preventing the development of discoveries can no longer be possible.

In conclusion let me emphasize the fact that legislation for the welfare of a key industry necessary to the well-being of a nation should not be considered as a political measure in opposition or in accord with the principles of either of the great parties—it should be looked upon wholly and solely as a means for the preservation of our nation.

DEVELOPMENT IN THE PRODUCTION OF DYES AND INTERMEDIATES

By EDW. HOLTON

Read at the Chicago Meeting, January 15, 1919

Prior to the war we were using rather large quantities of para-nitraniline and beta-naphthol together with lesser quantities of meta-nitro-para-toluidine, alpha-naphthylamine and other intermediates. We also used considerable quantities of various scarlet dyes, some eosine, alizarin, etc. At the outbreak of the war, we had quite a stock of these materials, in fact with careful handling, it proved to be more than a year's supply. Hoping that the war would be of short duration, yet wishing to safeguard our business, we at once began to consider the feasibility of making para-nitraniline and beta-naphthol for our own use.

After a few months it was decided to carry on experiments and some small batches of intermediates were produced. When the war was more than a year old and our stocks were being rapidly exhausted, active preparations were made to enter the industry.

After some search, an expert was found, buildings were erected and machinery and chemical equipment installed, a corps of chemists established and production commenced.

In a short time we were producing beta-naphthol, para-nitraniline meta-nitro-para-toluidine, other intermediates and various scarlets in quantities more than sufficient for our own use. We have sold to other manufacturers rather large quantities of some of these materials. During this period, like all others entering the industry, we have been forced to pay much higher prices for our raw materials than were paid before the war. Costs of construction, costs of equipment, costs of chemicals, costs of repairs have been excessive. Wages and salaries have been abnormal and the net result has been that our dyes and intermediates have cost us very much more than they cost us before the war.

In some instances if raw materials and chemicals were to be furnished free, the labor and overhead alone would amount to more than the pre-war price.

We believe that when peace is again fully established this new industry, the industry of synthetic organic chemistry, will be jeopardized unless definite and forceful steps are taken to protect it.

Protection by tariff alone will not be sufficient. It will be necessary to actually prohibit or restrict the importation of some of these products for a few years.

Moreover it is essential that there should be no conflict between the Sherman and Webb Acts and they should be so amended as to remove all ambiguity.

It is not merely a matter of protecting our citizens in the manufacture of a few intermediates or a few dyes or a few medicinals. It affects our entire chemical industry which has been built up tremendously as a result of the war.

If we are not allowed to rear our defenses, if we are not allowed to present a united front to the enemy's mass attack, all will be lost.

Our dollars, our health, our lives, our nation can best be preserved by maintaining our chemical independence.

DISCUSSION

Dr. TAKAMINE: Mr. Chairman, this is a great pleasure but it is a very unexpected one. I am just on the way to Japan, leaving here this afternoon. I just arrived this morning. I have only a few hours here in the city, but I want to spend every minute I have at this meeting because your program was of such a nature that the papers read and discussed will be of great value to my country. That is the reason why I stepped in here. I have just heard Mr. Holton's very interesting paper, and a very important one, too. Japan is in the same condition as you are, in fact many times worse, because whatever chemical industries you have developed within the last four years you have gone at it with such gigantic energy and success that a good many of the industries which you have already established within a short number of years, have grown to be big industries that are going to stay. In the case of Japan where we followed your footsteps the scale runs smaller, and while we have done everything possible in a chemical line, yet you can imagine the scale is very small. Consequently such protection, and other means of protecting

ourselves from the invasion of Germany, you can imagine, may prove hard to work out in Japan.

Japan has wanted to become independent in her chemical industry from Germany and Austria, so among several industries that sprung up the Government took a hand and they guaranteed an 8% dividend and some of them have made it go without Government help. The industry itself was able to make the desired dividend, but some industries are just getting on their feet and ever since they were organized it is the Government's money that has been paying the 8% dividend to the investors. The dyestuffs industry is also not in the category, although that can be expected to make a fair dividend this year without support from the Government. As you can see, it is just like a new born baby, and if it be attacked by German propaganda and German invasion all those babies will not survive I am very anxious to know what method we should employ. The English license law seems to me a very adequate one. As soon as I arrive in Japan I am going to have a talk with our people there and tell them you are also very much interested in this, and whatever you do will be a good example for Japan, not only in this thing, but a great many things. You gentlemen in the United States have been the leaders and have set a good example for the progress of the modern civilization of Japan. I thank you very much, gentlemen. (Applause.)

Dr. GUDEMAN: Mr. Chairman, I would like to take this opportunity of welcoming Dr. Takamine. I am especially glad to do this because my friend, Dr. Toch, of New York, is claiming Dr. Takamine for his city. Dr. Takamine states he is going to Japan. I want you to know that Dr. Takamine belongs to Illinois. This is his original home and the biggest part of the Takamine family come from Illinois, if I am not mistaken. We are very glad to see him. He has been here in Chicago and Peoria over twenty-five years ago and I want in the name of the Chicago section, particularly, to welcome him. I would like to have him put in the record as of Illinois, and not of New York or Japan. (Laughter.)

THE AMERICAN DYESTUFF INDUSTRY

By LOUIS JOSEPH MÁTOS

Read at the Chicago Meeting, January 15, 1919

Mr. President and Gentlemen: I am not going to read a formal paper. I think we have had enough formal papers. I was very much surprised when I received our little pink brochure from my good friend, Professor Olsen, to find my name on the program as one to make an address on the subject of dyestuffs. We have had during the last few years so many papers on dyestuffs that it seems difficult to present anything that you do not already know. It seems however, from the titles of the papers that have been submitted on the maintenance and preservation of our chemical industries, that dyestuffs do figure to some slight extent. It also seems that those who have been working with dyes and the intermediate products from which dyes are obtained, the raw materials and crudes that are ultimately converted into dyestuffs, have worked along narrow lines. I do not say that we have become self-centered, but perhaps all we can see is dyestuffs.

You have had this morning several papers of great depth that manifestly show a great deal of painstaking care in their preparation. I have not done that. I occupy a peculiar position in our company, being a factory man and not an economist. In the department that I have had under my charge, I had to take the intermediates that were delivered to us—some of which have been good and some have been worse, occasionally some have been better, and convert them into a few dyes, because you realize—those of you who probably may not have been brought in direct contact with the dye industry—that, as a matter of fact, very few dye chemists have made many dyes. We have had to limit our catalog of dyes to a few and specialize upon those few. Some chemists have concentrated upon basic dyes, some have concentrated upon the sulphur dyes, some upon the azo dyes, and so on.

During recent years, perhaps during the last twelve or fifteen

years, there has been considerable impetus given to the so-called vat dyes, a very important group and one that has not received in this country very much attention. That is unfortunate and I hope those of us who are interested in dye research may be able to induce our students to undertake some of the work, because it is certainly needed in this country. The Germans have outstripped us in that. They have gone ahead, and if you have studied patent literature you will find that almost in its entirety work done on the vat dyes has been concentrated in Germany. Few vat colors have been produced elsewhere. The great proportion of them emanate from Germany, and for a number of years Germany monopolized the field. Some chemists are working on it in this country and I think that those who have studied the broad field of the vat dyes see its great importance. In the dyestuff industry, broadly, during the last four years, or ever since the war broke out, the dye chemist has had remarkable loads placed upon him, and he has been working at high pressure.

Up to the outbreak of the war it was a very easy matter for our textile mills to obtain dyes by simply telephoning or telegraphing or writing to the importers to send a barrel of this or a ton of that, or a 100-pound keg of something else, and in two or three days they got it. It went into the dye house, and was turned over to kettle hands for use, and in due time the finished fabrics came out. When these stocks of dye began to run down, the mill simply repeated the order for more color. Some mills contracted for a year's supply, and in these instances there was less trouble. When the war came, what was the consequence? We did not have any very large stocks of dyes in this country. Some stocks were greater than was immediately needed, but everyone having dyes on hand sat tight upon them and these were doled out in varying quantities to customers on their books. In time those stocks were depleted with the consequence that the price of dyes rather increased, while the mills were putting their pressure upon the dye importers in this country. Some chemists had worked in dye plants on the other side and some had worked in the few dye plants in this country. Our friends in the textile trade, leather trade, wood staining industries—those industries where dyes were very largely used, said, "You are a chemist. Why don't you get busy and make some dyes?" It was very easy to ask, you know, but it was a very disagreeable question to answer because we were doing the very best we could under the circumstances. We did not

know how to produce many dyes because we did not have the necessary raw materials. The crux of the whole matter in this country has been the development of the raw material industry, the industry of the intermediates, and with the exception of aniline and a few other products of simple composition, we did not know how to produce them. Two of the most important naphthalene products, amido naphthol sulphonic acid and amido naphthol disulphonic acid; we did not know how to manufacture satisfactorily. We had the patent literature, together with the text-book literature, and we commenced operations. At the plant of which I was superintendent, *H* acid of a strength of about 20% was supplied and which we regarded as being fair, all things considered, although I had used this same acid assaying considerably above 90%. After awhile, however, as confidence and experience progressed, the assay value of the domestic acid increased so that in time, the quality of the dyes made from it likewise increased. One of the earlier dyes made with this acid was a direct blue, the product of coupling with benzidine, a very common dye with which you are all familiar. When the first shipments of this blue were sent to the grinding and standardizing departments, word would come promptly back to the factory, that the lot was "flat and weak." What could we do? With a defective acid containing sundry impurities the nature of which tended to the production of a color that was flat in shade, we could only wait until better grades were available. Later, we received grades of increased quality, and this gradually continued as experience pointed out errors in manufacturing.

Those of you who are engineers will appreciate the fact that we were unfamiliar with the design of some of the special types of machines necessary to make some of the intermediates that were wanted. Many of our dyer friends were a little impatient at our progress, but they are to be pardoned on account of their lack of knowledge of the difficulties of dye making. Many of them would remark, "Why do you not manufacture good dyes?" Our efforts were constantly directed towards better dyes, but we were limited both in experience and materials. We are doing our best to improve the quality of the necessary intermediates that were absolutely necessary. Few realized the great importance of the intermediates to dye making, and fewer still did not know that that industry had to be created in this country before dye manufacturing could make any practical beginning. Much has been accomplished in this direction,

and a great deal is now being done to enlarge the list of intermediates, which means a corresponding increase in the range of domestic dyes. As to the quality of the dyes now being produced in the United States from American made raw materials, it can be said that they compare most favorably with dyes of corresponding type that were formerly imported from Germany. Of course, there are some dyes that are not now manufactured here, especially of the vat-color group, but these will come along in time. The question has probably arisen in your minds as to what the American dye maker is to do after the war. We do not know. It is believed, however, that there will be a sufficient tariff to afford the amount of protection that will conserve the industry, and at the same time safeguard the parallel industry of the munitions that are so intimately associated with the dye industry.

Those of you who might have been at the textile show last May, or at the recent chemical exposition in New York, saw there a table of some seventy-five intermediates, each one practically an industry in itself with its own engineers and chemists. That collection represented the development of the most important part of the dye-stuff industry in America, and spoke most eloquently of the labors of those who were instrumental in its extension. Take "gamma acid." We are producing from it the first fast red that has been so urgently needed for cotton. We have succeeded in producing pure anthracene, from which is obtained the valuable alizarine, with which the dyes produces Turkey red. We are also producing anthrarufin, from which is made the most important fast blue for wool. You will pardon me in quoting Mr. Matheson, the President of the National Company, who should be here instead of myself. In a public statement which he made, it was stated that the cost of the blue referred to was about one thousand dollars a pound to produce, but that in time the cost would come down. This apparent great cost is due to the difficulties that have to be overcome. As a matter of fact, the actual selling price at this time is fixed at twenty dollars a pound, so that after all, some of us may wear garments dyed with it in part.

The same applies to quite a number of other products that we are manufacturing. I will not go into the details because it is an old story. We are between two fires. We are between the people on the one part who want something better than we can make at present, and on the other side, the people who want something to dispose of

again over in the market. Now the intermediate industry is the foundation of all this and we are trying to perfect that. Some of the dyes made from the intermediates that we produce—and when I say “we,” I mean the other dye makers. They are struggling with the very same problems, that we are, perhaps not on as large a scale though perhaps some of them have single products on a larger scale. We are trying to refine the processes and to concentrate all of our efforts upon the production of those dyes mentioned to you to keep our American mills going. Consequently all our efforts are devoted to that one point. During the period of the war we could not get tuluol. A little was released by the Government to be used in dye experimentation, but now we have all the tuluol necessary, and which will enable the manufacturing department to turn out a range of dyes numbering probably 55 or 60 in which tuluol forms an integral part. Then we will be able to produce what we are not producing at the moment, a range of colors that are of constantly increasing fastness.

Since the coal-tar dyes have been in use, the great majority of them came from Germany, and in the early days, as improvements were made in their manufacture, or as new discoveries were made, the older dyes became obsolete, and gradually disappeared from the market. These old dyes and those that came later gradually made up the list that appears in Schultze's tables, totalling a few over nine hundred dyes. When the American dye maker commenced operations shortly after the war broke out, it was frequently asked if it was thought possible for us to make the 900 dyes listed. Many even imagined that our mills could not operate unless 900 dyes were actually available. Out of the 900 dyes in the tables, probably 600 are in use as current colors, of which relatively few were manufactured in very large quantities, while the remainder were made in comparatively moderate quantities. We are now producing some of the simplest dyes, and are gradually increasing our knowledge and ability to make those dyes that are faster and have better qualities. That is where the struggle has been. We have had to train ourselves train our engineers, and bring them up to that point where we would have the ability to produce dyes of even greater value.

Referring again to the tariff. If the American people desire this industry to remain it is for the people to provide a tariff that will protect it against all foreign encroachments. That there are some dyes urgently needed is well known, but chemists are at work upon

them, and it is only a matter of time when they are produced here. In the field of vat-colors, much work is now being done, and gradually these will appear upon the market. I believe that a period of about five years should be considered when planning a tariff that has for its object the upbuilding of such an important industry as the one I am speaking about. Then we will be in a better position to know what the production costs are. We do not know them now, and can only hazard a guess. We do not know what it costs to produce very many of the colors that we are now placing upon the market. Perhaps in the course of about five years, then the heavy chemical industry will have settled so that we will know more accurately where we stand. It is a difficult problem, an extremely complicated problem, and one that cannot be handled at once, particularly when there are so many phases to it. I have tried to make this feature plain to you and trust that I have done so. I thank you for your very kind attention. (Applause.)

THE IMPORTANCE OF THE RESEARCH CHEMIST AND TEAM WORK IN DEVELOPING OUR CHEMICAL INDUSTRIES

By COLBY DILL

Read at the Chicago Meeting, January 15, 1918

Not very long ago the following advertisement appeared in a well-known technical journal:

"Chemist for food color department wanted by prominent firm; must be expert in manufacture of certified anilin and vegetable food colors, a long training in this business and an absolute grasp of its practical essentials desired. The *mere research chemist* need not apply."

I have read this copy to you not for the purpose of criticising the rather uncomplimentary reference to research chemists in general, but because it is an example of a state of mind which I believe is not uncommon among those who have the power to determine the policies of our chemical industries, and because I believe that wherever this state of mind exists in high places I think you will find there a chemical industry which is in need of maintenance and preservation.

You are aware that the months since the summer of 1914 have been months of intensive development of our chemical industries. Under the stimulus of war conditions, costly plants have been erected and put into operation without what we usually consider adequate knowledge of the chemical processes involved, and that these plants have been as a rule highly successful is a sufficient tribute to the courage and sagacity of their promoters and the resourcefulness of their chemists and engineers. Nor is it to their discredit that in the few months of their operation, handicapped by lack of men and the difficulties of obtaining equipment, they have not yet perfected their respective processes to such a degree that they can face with composure the competition of the longer established industries which before the war wielded control of their market. It is not surprising, therefore, that many of these new concerns cannot produce and sell their products as cheaply as their foreign competitors can.

If it were not so, there would be no occasion for this meeting.

If we should examine those industries which are in need of maintenance and preservation I think we should find that with a few exceptions they are operating chemical processes which are very intricate and require highly specialized knowledge. And the disadvantage of these new industries lies chiefly in the fact that they have not yet learned those refinements of equipment and niceties in the adjustment of operating conditions which bring the maximum yields at the lowest operating cost.

I am aware that a popular impression prevails more or less widely that foreign plants generally are more efficient than our own—even our own industries which are well established. Such an assumption is not supported by my own observation. On the contrary, I believe that our own engineers and chemists have shown themselves more resourceful and more progressive than their foreign rivals.

If it is true that the weakness of these new industries is to be found in the fact that they lack sufficient knowledge and experience in the process which they are operating, then the remedy, it seems to me, is to seek this information by intensive study.

As you are aware, the stopping of the munition program has released hundreds of chemists and engineers from government and private plants. Some of these men are among the most capable in our profession. Our own selfish interest as well as a decent recognition of what they have done for the country should impel us to take them into our organizations as fast as we can select men who are particularly fitted to attack our own respective problems of production. And so, my first suggestion for meeting the situation before us is intensive research work.

My second suggestion is a plea for more team work.

A winning team in industry presupposes that each member of the team has been selected and trained because of his peculiar fitness for that particular position—that he is, therefore, a master of his craft, superior to all others on that team in his particular field of endeavor. In addition, team work presupposes that each man plays his position not alone by himself but in conjunction with all the others, each man helping all the others and being helped by them in turn by the exchange of ideas. The driving power of a team is equal to the collective brain power of its individuals raised to the n th power, where the exponent n represents their degree of co-operation.

Co-operation in industry means something besides this; it

means *recognition* of the individual who has made good, whether that individual is a mere research chemist or a mere sales manager or a mere foreman in the plant or, for that matter, a mere executive officer. In its application to research, recognition means specifically, as Dr. Parsons has pointed out some time ago, that Boards of Directors must raise their most responsible chemists and engineers from the status of mere employees to a status of partnership.

If our chemical industries will adopt toward their manufacturing problems such a policy of intensive study and if among their men they will develop the spirit of team work and if they will resolve to give recognition, financial and otherwise, wherever it is due, I will venture a number of predictions:

First.—That chemical engineering education in our universities and technical schools will be greatly stimulated.

Second.—That our chemical industry will attract an increasing share of the best new blood from the graduates of our technical schools.

Third.—That American chemical industries will be not only preserved in their present status but during the years to come will show a continued healthy growth.

THE ENAMELED STEEL INDUSTRY

By WM. ZIMMERLI

Read at the Chicago Meeting, January 15, 1919

Like almost all industries the enameled steel industry has received a hard blow due to the war. It is practically the same in the enamel industries as it was in dyes. The people wanted enamel-lined tanks for acid work and they wanted these things quick. That meant that in a good many cases, before equipment was satisfactory from our point of view, we had to make shipments because the people did not care about pin holes or anything else. What they wanted was the tank. Now that is not an alibi at all, but it is a fact. The manufacture of enamel-lined equipment, especially large ware, is not standardized as to size and shape. Each party desiring a tank has a special design and the tank has got to be constructed specially. It means that a special drawing has to be made for it which takes some time. It means that the tank has to be built by welding together sheet steel and this requires expert welders, because it is a difficult thing to enamel over a weld unless the weld is made satisfactorily. Then after the tank was constructed it had to be enameled and this is to a certain extent a long drawn out process, because to get an acid resisting enamel on a tank it is not a case of just putting the equipment into a furnace and burning the tank. It means burning the tank ~~with~~ a first coat and burning it with two cover coats and sometimes a good deal more than that before the tank is ready to be shipped.

Now then the war has hit our industry in this way: It has taken away some of our welders. They had to be used for ship building and other equally important war industries. Of course, shipping was more important than anything else and welders of all kinds had to be taken away from us and we had to train new welders. That meant delay in manufacture, because when there is a defective weld it means that the whole operation has to be gone over again. If a defective weld appears it can only be detected, at the present time,

after the tank has gone into the furnace. It means that the enamel has to be blown off and be rewelded. That means delay and it meant trouble all around. However, I think that things are straightened out now. We can take a little more time in manufacturing and I think that shipments now will be more satisfactory. The enamel-lined steel equipment has had a great boost in this country due to the war, in that people manufacturing on a large scale went into it bigger than the Germans did because they did not have acid-resisting enamel for steel. As far as I know they were satisfied with small equipment which could be made of cast iron. They wanted a tank of 2000 gallons capacity in this country which could not be made out of cast iron. For small ware the enameled cast iron is now being made in this country and it is my opinion that as far as the manufacturing of enameled equipment of all kinds for acid ware is concerned this country is going to have it on the Europeans within a very short time. (Applause.)

FUTURE OF THE BARIUM INDUSTRY

By HUGH ROLLIN

Read at the Chicago Meeting, January 15, 1919

The future of the barium industry, to my mind, is almost entirely dependent upon whether the Government raises a protecting tariff or not, and it seems to me most appropriate that we should proceed without very much delay so as to get our houses in order against the time when this country will have tremendous competition in those materials which we have made since the beginning of the great war. There are several contributing causes which lead me to think this.

The barium industry in this country is in its infancy and has not had time to become well established or financially strong. The makers of machinery suitable to this industry are lacking in experience and many of their products appear quite crude in comparison with some of the European machinery, and then, for some strange unknown reason, barium products have always been manufactured on a very small margin of profit and this, in conjunction with the fact that wages in the United States are at least 100% higher than in other countries, would indicate to me that, without the above-mentioned tariff wall to shelter behind, the barium industry will cease to exist in this country in the very near future.

The question of freight rates will also play an important part in determining the future importance of this industry, for we must remember that the consumer can afford to buy our goods only if they are as good in quality and as cheap as the foreign goods.

Now the tendency seems to be for our railroad freights to keep rising and I see very little hope of their being reduced, especially under Government supervision, which, as we all know, is uneconomical and more expensive than private management. On the other hand, the end of the world war leaves the shipping of the world in better shape than it ever was.

OCEAN FREIGHT WAR FORESEEN

For the first time in many years the American mercantile marine will enter into the race as a serious competitor against Great Britain, France and Holland. I foresee in the near future an ocean freight war, which will make transportation by water extremely cheap, and if this takes place it will, of course, do its part toward annihilating the barium industry in the country, provided the industry is not given proper protection.

We have information from Europe that the various Governments there are encouraging the consolidation and amalgamation of various interests engaged in the chemical industry, purely with the idea of strengthening their position and their financial condition and putting them in a position to effect great economies in overhead expenses, all with a view toward invading the world's markets with their products and preventing, if possible, the balance of power in the chemical industry from swinging to America.

It is quite obvious that an industry of this kind, which now employs a small army of men, should be maintained and preserved in such fashion that the industry can live, and I would suggest not only tariff protection, but laws which will permit the responsible manufacturers in the same line to meet and discuss freely the costs and selling prices. On the other hand, we, in the United States, are up against the Sherman anti-trust law and numerous other laws of like character, which forbid and make criminal any effort at consolidation or co-ordination of interest and prevent any steps being taken to form the various units of the several branches of the chemical industry into any kind of a league for their self-protection and preservation.

I should, therefore, recommend as a relief and as a protection, that immediate attention be given to our needs by the legislators, and while I do not ask for an excessive tariff at once, I feel that for economic reasons we must have protection, not against Germany alone, but against those other countries which are now ready to compete under a lower wage scale and with cheaper freights.

The system of taxation to which the Government has resorted to meet the expenses incident to the great war, while no doubt very efficient as a medium of obtaining money, is, in my opinion, ill-advised in some respects, in so far as it seems to bear down with undue weight upon manufacturers in general. This pressure is felt most acutely by such new industries as our own. We find a difference

between our Government and the Governments of European countries, who in an endeavor to help and stimulate their growth, in the case of many young industries, declared them to be tax-free until the time that they are financially capable of bearing their proportionate share of the country's expense.

As far as the volume of business is concerned, the barium industry is active or inactive in direct proportion to the business activity or inactivity of the country as a whole.

Barium products, including barium peroxide, barium chloride, barium nitrate, barium carbonate, barium sulphide, etc., depend for their sale on so many diversified interests that the volume of business which can be done in them is a very good index as to the general condition of business throughout the country, and the stoppage or the elimination of the barium industry would have a very deleterious effect on a great many other industries. For instance:

BARIUM PRODUCTS USED IN MANY INDUSTRIES

Barium peroxide is used in the times of peace for the manufacture of U.S.P. hydrogen peroxide and as a bleach, especially in the straw hat and blanket industries.

Barium sulphate (precipitated), known in the trade as *blanc fixe*, is used in the manufacture of automobile tires, in the paper industry, in making printer's ink, in pigments and in many other ways.

Barium sulphide, also known as black ash, is used with zinc sulphate to manufacture lithopone.

Barium carbonate has widely diversified uses in the manufacture of scumless brick, in rat poison and high grade optical glass, etc.

Barium chloride is largely used in the dye industry, is absolutely necessary in the manufacture of photographic materials and enters into the manufacture of a great many other chemical compounds.

Barium hydrate finds its largest use in the beet sugar industry.

Barium nitrate enters into the manufacture of fireworks, detonators, railroad signals and, of course, enters very largely into munition making, as well as having numerous other peace-time uses.

Sodium sulphide, while it can scarcely be talked of strictly as a barium product, is, nevertheless, available as a by-product of the manufacture of certain barium products. It is absolutely essential to the making of sulphur dyes and is the most extensively used depilatory in the conversion of hides into leather.

I have only mentioned a very few of the uses of barium products, but enough, I hope, to allow you to readily see of what importance these uses are and to give you an idea of the necessity of making conditions such that the barium industry will not perish.

To sum up: To put the barium industry on a sound commercial basis in this country we require, first, a strong tariff wall; second, reduced freight rates; third, the right to organize, and fourth, a little more consideration from the Government in the matter of taxes. Given these four items, I would say that the barium industry in the United States has a great future.

RECONSTRUCTION-ASPECTS OF SOME CHEMICAL INDUSTRIES, IN THE UNITED STATES, TO-DAY

By EDWARD GUDEMAN

Read at the Chicago Meeting, January 15, 1919

It often takes a major operation to save the life of a person or that of a nation. The glorious outcome of the war has not alone saved the life of our people, but has been the salvation of the world, has amputated the heads of autocracy, sounded the death-knell of the cankerous German confederation, and in doing so has saved the lives of the German Nation, which they do not seem to recognize as yet, but for which their coming generations will thank and bless us.

This heroic military operation brought to life the American chemists, who two years ago were hardly known by name, but who to-day stand before the world in full man- and womanhood, the equal of our fellow-chemists in any of the four quarters of the world. The horizon is still too near, and the time elapsed too short, to tell what the United States chemists have done to help attain a mastery of the air, on the earth's surface and below its depths, land and sea. This must be left for coming historians of chemistry. We are now in the most critical after period of this military operation, in the convalescent stage, and whether we fully recover and become economically, socially and industrially stronger, in fact whether we survive or not, for the benefit, welfare and prosperity of ourselves and coming generations, depends on what we do Now, on our RECONSTRUCTION program, its construction and operation. It is not with us a question of readjustment nor rehabilitation nor of reclamation, it is reconstruction, although many problems belonging to these other phases must be considered and incorporated into our reconstruction program to prevent duplications and interferences. Our reconstruction means CONSTRUCTION of a structure that will *justly* and *fairly* meet our present and coming social and industrial problems. It cannot be a plan of one or a few, and we cannot expect to erect it within a day or a week. To-day we can, and must lay its

foundation stone, anchored firmly on a bed-rock of justice and equality. We must act as a unity and give up our present day national policy of "Let George do it."

We know that we were not prepared for War, and none will deny that we are now as little prepared for Peace. We face conditions and problems that necessitate the erection of an edifice, on the very firmest economic and social principles, but at the same time so flexible that it will withstand all the pressure exerted thereon from all directions. We must erect a solid and flexible Reconstruction Fortress, with a full supply of ammunition, most of which will be chemical.

The statement that "Money Wins Wars" has been shown to be false. It was LOYAL man and woman power, abroad and here, inside and outside of uniforms, to whom the victory must be credited. No class, no profession and no sect can be singled out, and what I claim for our profession, others may deny, or claim for theirs.

Chemistry helped to create our powerful navy and our new mercantile marine, and we must do our best to see that neither of them remain at a standstill, that both continue to multiply. To-day the United States Flag is flying on all the seven seas and never again will leave them, with or without a "Liberty of the Seas" whatever that may be or mean. To-day every land and waterway is open to us, and must be kept so for us to take our place and have our share in a world's commerce.

Months before the signing of the armistice, Lord Inchcape, then president of the Chamber of Shipping of the British Empire, called a meeting of British Colonial editors, and his choice of the publicity men of Great Britain was not accidental, to whom he said—"America has been building at a great rate, and he was afraid of what the (British) position may be when the war was over, and he called this meeting of editors to consider the question of their position after the war." An immediate editorial reply was given him by the non-colonial English Morning Post, viz:—"An ally of to-day, may become a serious, though friendly, trade rival." Let us reverse the suggestion and see to what extent our war allies of yesterday, have become serious trade rivals, perhaps friendly trade-enemies. We all know that at the signing of the armistice, during the time of war, large stores of all kinds had accumulated and were isolated in the Southern Hemisphere and in the Far East.

Immediately with the release from military duties of a very large

number of ocean carriers, these stores became accessible and available and are now floating back through the old commercial channels into their former markets. Great Britain and France are taking advantage of these national opportunities, perhaps national obligations, and are cutting away from the United States, except so far as pre-war contracts and immediate necessities, compel them to still deal with us. Commodities bought by foreign nations, and still in our country, are being resold to us at reduced prices. Foreign governments are cancelling ship charters, ships that we expected to use to bring back our soldier boys, these ships being worth more to the allied nations as freight carriers.

Within thirty days after the signing of the armistice, negotiations were completed between Argentina and Great Britain and France, for the whole wheat crop of that country, and to facilitate payment, Argentina is said to have loaned \$240,000,000 for two years to England and France. Our government may have to make good to the extent of \$1,000,000,000 for our coming wheat crop, as a \$2.26 price was guaranteed to our farmers, being about \$1.00 per bushel above what the Argentine crop was sold for.

Sugar is on its way to England from Java and Australia. But we will hold the bag for the Cuban crop as we guaranteed a fixed price for it, anticipating that England and France would take not less than 40% thereof. Our Food Administration has removed all restrictions as to sugar and wheat consumption, and we need anticipate no shortage, in fact, the *more we consume now and the more we waste*, the lesser amount our government will have to make good. As a perfect commercial reversal of action, let me quote Mr. Herbert Hoover's anticipations,—“We can do no less than fill (with food stuffs) the ships they (our allies) send us. Of our imports we shall apparently have sufficient sugar to maintain the present consumption (then 2 lbs. per month per capita) and take care of the extra drain of the Allies from our markets, instead of COMPELLING them to send their ships to the Far East.” (“Geographical Magazine,” Sept., 1918.) No blame rests on the Food Administration for this anticipated compulsion of going away from us, having become a foreign inclination, with financial advantages. Argentina and Australia are now shipping meats to Great Britain at 6 to 10 cents below our export prices. Great Britain is more of an asset to the Southern Hemisphere and the Far East than the United States. Friendship and Commerce easily mix especially when the preference

is shillings and francs, instead of dollars and cents. To protect ourselves, whether chemists or not, our reconstruction program must extend in effect beyond the boundaries of our own country, and we must make a part of our policy, the underlying principal announced to his country by the British Minister of Reconstruction, namely: "That the problem of reconstruction begins with shipping." Great Britain has not alone had a Minister of Reconstruction for many months before the signing of the armistice, but also has in its cabinet, ministers or secretaries for: Overseas Trade, Development and Intelligence, Board of Trade, Local Government Board, Education, Shipping—all specific war and after-war officials. What have we done? We have appointed uncountable committees and commissions, representing, federal, state, county, city, trade and local boards, many unable to see beyond their local horizon or their individual interests, some even with political aspirations. Such narrow, local, selfish or political bodies, and reconstruction, will not make for constructive nor conservative bed-fellows.

Anyone whether chemist or non-chemist can enumerate many problems that must be solved by our reconstruction program, among which are:

1. The moral and patriotic duty and obligation of the reconstruction program, to put back into industry and commercial fields, every soldier and sailor, who in any way become incapacitated, due to the war. We must enable everyone of them to earn a decent living and become independent. We cannot make any distinction as to where he or she was incapacitated, here or abroad. This is a demand, which everyone of these men and women can justly insist upon, and this demand we must meet. There can be no consideration as to what our government, through the War Insurance Act or otherwise will do for them.

2. Our reconstruction program must give encouragement, assistance and protection to all NEWLY established or NEWLY developed American Industries, many of which if not directly chemical, have a chemical underlying basis. Exclusively war industries, we can set aside or ignore.

3. A reconstruction program that will conserve our NATURAL RESOURCES, and our RAW MATERIALS. This must be based on broad, sound, economic commercial principles, so that finance will come to the assistance of developing industries, not alone from private sources, but from the government, perhaps through loans, subsidies

or some other form. We must have Federal protection to small and large business, perhaps through properly regulated and controlled federal incorporation. Mr. Frank A. Vanderlip, one of our greatest financial authorities, has recently stated that it would be necessary for the United States to extend a liberal credit to the Allied Nations. He said "We must make great shipments of food stuffs, of RAW materials and in a LESSER measure of MANUFACTURED products immediately after the war, and they cannot be paid for by equal shipments of goods to this country. Payment must be made to us through bonds and securities." This is very true from his viewpoint, finance, but it does not go far enough. Especially now, right after the war, for the protection of our industries and for them to hold the positions they have created for themselves, we should be very conservative in the shipments of our RAW materials, especially from NATURAL resources, and most liberal credits should be extended to our own home manufacturers, to enable them to EXPORT their MANUFACTURED products. We should never again ship our NATURAL resources and our RAW materials in bulk, car-load lots, away from our country, and then take them back in changed form, manufactured form, in ounce packages; not alone take them back as manufactured products but have to compete with them, not alone in foreign markets, but in our own. The manufacturing capacity of the United States, pre-war conditions, was said to be not less than one-third more than its consuming capacity. We got it in the neck both ways, first going, raw materials, and then coming, manufactured products, made from these same raw materials.

The relative standing of a country among the nations is dependent on its ownership, conservation and control of its raw materials and natural resources. The break through at Chateau Thierry sealed Germany's doom, not alone because it was a great military victory, but because it drove the opening wedge into Germany's commercial position, driving the Huns away from necessary raw materials. After Chateau Thierry it was a foregone conclusion that within a few weeks or months, Germany would be back beyond the boundaries of 1866 and 1871, and with the loss of those stolen territories, would have to face physical and commercial starvation. Deprived only of two chemical essentials from these territories, coal and iron, new Germany, whatever its political and geographical boundaries may be, will never again be a menace to the world,

never again can gain a commercial ascendancy, and will take her proper place, a minor power among the nations.

4. Health problems of to-day are very chemical, and they must have a strong plank in our reconstruction platform, not alone as to the prevention of disease, but as to the protection against disease. We must incorporate in our platform the problems pertaining to sanitation, housing, vital statistics, birth registration and other social, semi-medical health reforms. We must have interstate health regulations as a regular requirement, and not only as an emergency call on our Federal authorities.

A national health administration should be organized, not on strictly medical lines, but following the lines of our past food administration, educational, bringing health teachings right into every household. Every food expert, good, bad or indifferent, gave her or his services free to the Food Administration during the time of the war, but the real, effective work was done by the laymen, mainly women. A National Health Administration should have the guidance of the medical profession, but the real work, house to house work, must be done by properly trained laymen and women. We can as easily distribute Health literature, cards, bulletins and other information as we distributed among the masses food information and gave food demonstrations. A beginning has been made by the lay-workers, and many of the medical fraternity concede that the results obtained have been excellent.

5. It is an absolute necessity that our reconstruction program include a wide educational policy. We must have compulsory education as a fact, and the education must be in ENGLISH. We must obtain real Americanization of all those who need it, including our foreign-born citizens, coming immigrants, not overlooking our illiterate mountain white population and our negroes. It should never again be possible to raise whole regiments of Americans, to whom commands have to be given in foreign languages, but don't forget that not one of these soldiers or sailors, failed to make good when called upon, although you and I would have to know at least 30 different languages to correctly pronounce their names.

I do not believe that the suggestion is too radical, to require that every newspaper and every magazine that publishes articles in foreign languages, be compelled to parallel the same, with a correct translation in our country's language, English. Some such requirement would quickly do away with actual "foreign" com-

munities existing in our midst, containing people not even able to swear in our expressive American mother tongue.

6. Transportation problems interest us directly, as all commercial movement, whether commodity or speech, requires fuel or electric power, and we are directly, vitally interested in the economic generating of both powers.

7. Economic Equality. This is perhaps the greatest and most important problem to be considered in our reconstruction program and everything can be included therein. Chemists are only a very small number of those who must help solve the questions as to labor and capital.

Women are to-day acting in many industries, and as chemists, the records show that they equal the men-chemists as to efficiency, capability and reliability. We are therefore directly interested in the adjustment of man's and woman's labor. This great problem of the replacement of the one by the other can only justly be solved through personal considerations, individual selections, and cannot be at the expense of the one or the other, man or woman, as a class, a sex consideration. And we must bear in mind that most, if not all, men and women, are interested first of all in themselves. Child labor Must be regulated; should be eliminated.

Economic equality is of international scope. It effects not alone industry, but political and diplomatic questions, such as reciprocity treaties and most-favored nation acts, which immediately point to customs, taxes and duties, immigration and emigration, day of labor and minimum wage scale. In fact economic equality is of such magnitude that it may be a consideration in the coming Peace Treaty and can be made the Preamble of the Constitution and By-laws of a League of Nations.

Let us consider a few problems from a narrow viewpoint of our own, the chemical profession; let us see where we actually now stand and what we may do to become a moving force in solving some of these problems, to make our profession molecules, if possible foci, in this coming industrial and social revolution.

Nothing pleases a child more than to be able to say "I told you so," and I admit of being childish. At a meeting of the American Chemical Society in April, 1914, I asked the question—"What is the standing of the chemists in the United States, not as we see ourselves, but as others see us? In fact, do we as a profession, exist at all? Is it not time (1914) for the chemists to get the recog-

nition due them and to place the profession on the high plane it should occupy? In Illinois the only two SCIENTIFIC professions that may be followed by anyone without license, permit or qualification to practice, are those of COOKS and CHEMISTS." (J. I. & E. Chem., Aug., 1914.) To-day we are better known and stand on the high plane we should occupy, but as to qualifications and requirements asked of us as a profession, there has been no change. In fact many are acting as chemists to-day, who do not really know what the word chemistry means, who have had no training therein, not even that of a school of correspondence. We have no official, legal standing, and consequently no professional responsibilities. We are not in the same class as other professional men, such as pharmacists, engineers, ministers, lawyers or physicians. We are not required to pass any examinations nor to obtain any licenses to practice. We do not have to even qualify same as chauffeurs, plumbers, elevator operators or barbers.

Now is the time for us to start something, while our chemical iron is still hot and while we are in the public eye. Blame and credit is now given us for some things, and the public and press recognizes we were part of the war's necessary implements. We can to-day assert ourselves and make our temporary war position a permanent one, and hold the position we have created, by becoming a constructive force in the working out of our reconstruction problems. We have now strong numerical and very influential backing of the other unrecognized scientific profession, the cooks. They have been dependent on us, due to our scientific control of their raw materials, the food stuffs. No one can forget the slogan that "FOOD WILL WIN the WAR." We backed the cooks, not less than 20,000,000 kitchen soldiers, all real commanders, and we taught them more about food and feeding, than they ever dreamed of since their existence in this country, say 1492. Many professional cooks, especially those outside of their own homes, have the advantage over the chemists, of being able to join a labor union.

Chemical terms, such as proteids, carbohydrates, vitamins, calories, are to-day common household words, and the infant knows the meaning of the chemical verb "to Hooverise."

In a talk to the Chicago Association of Commerce September, 1914, (their Bulletin Oct., 1914) and to this Institute December, 1914, (J. I. & E. Chem. Feb., 1915) I used the same title as to-day, without the word "Reconstruction." Conditions then pointed

out effecting our profession, at the beginning of the war, have not changed, except so far as war measures, mainly TEMPORARY, have for the time being modified them and given temporary relief, and unless we can make many of these measures permanent, we will again drop back into our old rut, and become chemical nonentities. Those statements of the past apply to our future, that—"In many cases, not all, Federal requirements restrict us, as to actually prohibit and stop us from manufacturing and going into competition with, and replacing imported articles. . . . Patent, trademark and copyright acts, with internal revenue acts, stand in the way, firmly braced by the Sherman act. . . . You can convince yourself of this by a study of those (chemical) industries in the United States where this interference, this prevention is not felt." The Trading with the Enemies Act, gives some relief, annulling for the time being our patent acts, but this is limited, requiring a government license, with safeguards to protect the former owners, as to royalties and profits. Restrictions under the Sherman act, Interstate Commerce Act, Food and Drugs Act, and some others, affecting interstate commerce, have been set aside, during the time of the war and perhaps a limited time thereafter, but many of these temporary privileges have already been withdrawn, and many who were active in the enforcement of these temporary reliefs, have received complimentary letters for PAST services. Some quasi combinations of large industries are still in effect, not through combination or unification on their volition, but by compulsion, through government control, such as the powers to regulate distribution of fuel and food, a partial control over labor and its employment, through military and industrial powers, regulation of farming and mining industries and their products, by fixation of prices and priorities, control of patents, trademarks and copyrights through the license system, and powers of the Alien Property Custodian, and the absolute control by the government of land and ocean carriers, including the telephone, telegraph and express companies. We also have government ownership of many miscellaneous concerns, mainly essential to direct army and navy needs, such as navy-yards, arsenals, shipbuilding plants, munition works, nitrogen-fixation plants and others.

Powers delegated to the War Finance Corporation, Emergency Fleet Corporation, War Industries and War Labor Boards, Food, Fuel and Railroad Administrations, Chemical Warfare Service

Branch, and others, should not be dropped without substituting something therefore, especially during our reconstruction period. We have the Webb Act as a permanent measure and it will no doubt be of commercial value, although it sets up a dual standard for business. This act nullifies the Anti-trust Act, allowing combinations or trusts in the United States, but only to do foreign business, only as far as export business is concerned. Now if it is good business to allow trusts or combinations to obtain a foreign market, why will it not be of equal benefit to us to allow regulated and controlled combinations at home, to enlarge and hold our own home markets? Why not have big business, like charity, begin at home? Why not enable us to better meet foreign competition at home, especially if thereby we protect our manufactured products and conserve our own resources. The Webb Act allows us to combine to dump our goods in the open foreign markets, but in no way prevents foreign goods from being dumped in on us. This dual standard of doing business, permitted, in fact fostered by the Webb Act, may again bring about the condition that we can re-import, duty free, exported products, at a lower price than we can get them at their original home source of manufacture. This act may become a boomerang, if not a Frankenstein, especially if raw or semi-finished product are involved.

At the Paris Economic Conference in September, 1916, a plan was considered by the Allies to restrict the markets of the then Central Powers, and it was proposed to deprive German industries of raw materials, by conserving for themselves "their natural resources and establishing special arrangements to facilitate INTERCHANGE of these resources."

Commercial history shows that national trade wars are as destructive as military wars, but that measures of defense are necessary to prevent a nation's MANUFACTURED products from being discriminated against. Perhaps we have magnified or exaggerated the importance to us of foreign markets for our RAW materials, compared with our MANUFACTURED products, exactly as we fooled ourselves as to our dependency on imported foreign manufactured products. If we were the largest market for the outside world's manufactured products, why not make them our market for our manufactured products? Which we can do by restricting exports of raw products and of natural resources, unless it is an interchange of such commodities.

Around each nation centers its force of race unity (our coming Americanization), its literature, its language (and ours must be made English), its political ideals, its national customs and its national commerce. We must therefore consider an opposite to the Webb Act, a strong and effective Anti-dumping act, adequate to protect American industry from unfair foreign business methods, and this is a necessity more so for chemical industry than any other. Some international agreement defining and limiting unfair methods of doing business should be formulated, which could be enforced through government supervision, control and regulation of export associations, allowed under the Webb Act, furthering American interests at home and in the world at large.

Many of our war measures and their enforcing bodies have been given up or are non-active, and nothing has been substituted therefor. Great captains of industry, labor, finance, and every other big business, are returning to their former pre-war occupations men such as Messrs. Schwab, Ryan, Baruch, Hurley, Piez, Insull, Rosenwald, Gompers, Edison, Carty, university, bank and railroad officials, not omitting our chemical representative, Dr. Nichols. It would be of interest to figure out a fair payroll for the services of these men, including also those who gave their services to National and State Council of Defenses, Red Cross, War Community Service and other official and semi-official bodies.

It was a chemical war and must be a chemical reconstruction, and to our profession is offered now a greater opportunity than the war gave us, and which we so successfully took advantage of, and whose every requirement we so fully met. As to chemical problems that confront us, only a very superficial and narrow review can now be attempted, individual cases cannot be considered, such as changing a synthetic phenol factory into one making rose oil or vanilla extract, or the rebuilding of a "real" flexible-glass works into one making non-losable golf balls, and our mutual friend Prof. Baskerville will admit that changing the lubricating and illuminating product from a brewery into those of an oil refinery, is of limited individual importance only.

The most important chemical reconstruction must come in the teaching of chemistry, not alone in our universities and colleges and technical schools, but beginning in our preparatory schools. Dr. Henry S. Pritchett, President of the Carnegie Foundation for the Advancement of Teaching, in the preface to Prof. Chas. R.

Mann's Bulletin on "A Study of Engineering Education" very forcibly says:

"In the half century that has passed, this course of study (engineering) has been overlaid with a number of special studies intended to enable the student to deal with the constantly growing application of science to industries. While the original plan remains as the basis of the teaching in the four year engineering curriculum, the course given in most schools has been greatly modified in the effort to teach special subjects. As a result, the load upon the student has become continually heavier and bears unequal in different places and in different parts of the course. In addition there is a wide-spread feeling that under this pressure the body of the students will fail to gain, on the one hand, a satisfactory grounding in the fundamental sciences; on the other hand, do not fulfill the expectations of engineers and manufacturers in dealing with the practical problems with which they are confronted on leaving the engineering schools. . . . The report is published by the Carnegie Foundation as a work of cooperation with the great engineering societies, with the hope that the formulation of these important inquiries and their discussion may lead to a serious effort on the part of those having to do with the engineering education to re-examine the curricula of the schools, and to approach the problem of their improvement not only from the standpoint of the teacher, but also from that of the practicing engineer and of the employer."

Have not the last two years shown that this applies as strongly to chemistry as to engineering? We all know that before the war, there was a strong fence dividing the theoretical, research and pure chemical scientist from the practical, commercial and industrial chemist. A few outsiders, some connected with technical schools, some in large industrial laboratories and a few individuals, straddled this fence, often leaning to those on the one side, and shortly after leaning to those on the other side, seldom doing anything to bring the two factions together, in fact, often finding it to their advantage to keep them apart.

Commercialism of chemistry was very abhorrent to many of our teachers of chemistry. German chemical pre-eminence was not due to any superability or super-mentality of her teachers of chemistry, or any other science, but it was due to her taking immediate advantage of, utilizing and developing, for her industries, every advance in scientific attainment. No one can point out any

new fundamental scientific discovery made by any German scientist within the past forty years. Many scientific discoveries have been claimed by the Germans, who simply appropriated them, developed them and APPLIED them in their industries. Recent laws of chemistry and physics were discovered by the Dutch, Norwegian, English, French, Italian, Japanese, Canadian and American men of science. Every German industry, commercial business, and the German government, and every industry, supported the university. It was considered an honor for German university teachers, from the head professor down to the most recent instructor, to be on the payroll, to be in the employ, of some industrial concern.

But the change in our teaching cannot be confined to our educational institutions, it must also embrace our employers and employees. We must develop a scheme for adequate training of workers so that their versatility, efficiency and productivity will be increased—a mutual advantage to capital and labor. We must have an association, a coalition or a combination between labor and capital, not alone practical—physical, but also mental—educational. This is particularly true for communities that have localized industries, even if of national import. A special kind of labor, creating a special class of skilled labor, tends to indifference towards education. This is well illustrated in many of our “cultured” New England cities. In Lowell and Lawrence, Mass., where we have a quasi monopoly, a one-kind of manufacture, you will find only one high school per 100,000 people. In Springfield, Mass., a city of equal population, with diversified industries, you have three high schools. It is also found that attendance at colleges and universities is less in proportion from communities having a monopoly of manufacture as compared with those having diversified industries. Educationally, labor is at a disadvantage, generally by its own volition, in communities where the preponderance of industry is of one kind. This is more true for the older cities, where an industry has grown up, not been transplanted.

We had different classes among our chemists, some two years ago, and the contempt shown each other by the members of these factions, was mutual. To-day this is all done away with, and the separating fence is gone. There is no chemical laboratory, collegiate or university, of corporation or individual, whose chemical staff was not temporarily badly disrupted. From youngest instructor to head professor, from wash boy to chemical director, all gave

their services to our government, volunteering and enlisting, with or without commissions. These chemists, men and women, are returning to their pre-war industries and activities, and they will insist on a radical reconstruction of the chemical curricula of our institutions, and leading you will find our present chemical teachers. These factions have been in a well agitated chemical melting pot, and the resulting alloy is pure and homogeneous, and this new *human* metal shows no line of segregation.

We are sure that our new mutual comrade in chemistry, Prof. X. Y. Z., having served our government, perhaps having perfected a new water-proof coating for air-ship wings, assisted by a former stock yards chemist, or having supervised the making of deep sea bombs, with the help of a fermentation expert, or reconstructed a gas-mask, co-operating with a fuel specialist, will not, when again taking charge of his chemical department in the university, be satisfied to accept for a doctor's degree a theses describing a new compound containing $23\frac{1}{2}$ carbon radicals, arranged in a parabolic curve, and some 57 varieties of salts made therefrom, all ready to be nicely hidden away in the cellar of the chemical museum of his alma mater. Nor will the practical chemical cuss, run and dodge, or take the other side of the street, when he sees Prof. X. Y. Z. in the far distance. None of us can foretell the tremendous influence a reconstruction of chemical teachings will have on our future industries. This war has conclusively shown us that—"Real, genuine research work and chemical manufacturing experience go together, are absolutely dependent on each other, and are the foundation of the development of chemical industries." (E. G., 1914.)

Reconstruction in the teaching of medicine must also come, and it must follow chemical lines. Recent practice of medicine is directly chemical, including bed-side medicine, even the before and after treatment in surgery, both as to diagnoses and operation. Preventive medicine depends on products originated and produced in the chemical laboratory, whether a direct active medicinal preparation, or a serum or anti-toxin. Internal medicine is based on chemical and microscopic analyses, which may be a blood count or analysis of the stomach contents, or the making of a direct coal tar color in testing the urine by the indol reaction. The first treatment of the wounded on the battlefield is chemical, use of iodine, and in the base hospital the Carrel treatment, using the Dakin

solution, depends on the action of chlorin. The excellent health conditions in our army and navy, at our camps and cantonments were due to chemical means, even if camouflaged under the name of sanitary methods.

Little authentic information is at hand as yet in regards to the damage done through the illegal, brutish, foul and inhuman use of poisonous and noxious gases. Full responsibility for this dastardly method of warfare falls on the German chemical serfs, who with their former owners, the instigators of the war, should be given a dose of this, their own medicine. Prospective medicine will have to consider the effects caused by these chemical, death-dealing and health-destroying gases, and it is not improbable, that within a reasonable time, perhaps these and other chemical gases will be used to obtain beneficial results, and be used legitimately as health-restoring agents, especially against infectious diseases of the respiratory organs, and diseases transmitted to the system through the nose or mouth.

It may be wrong to draw the conclusion, but the suggestion is not out of place, that the relatively small number of cases and fatalities, due to influenza, among the allied troops on the Western front, was partly due to the peculiar antiseptic character of the atmosphere there, not alone due to the poisonous antiseptic gases actually used in warfare, but also to the gases generated by the ammunition daily exploded. If the use of war gases had such effects, then unintentionally and unknowingly the Huns perhaps saved more lives than they destroyed by gas warfare. This view is supported by the meagre circumstantial evidence, that at the second battle of the Marne, the turning point of the war, the German contemplated advance was retarded for 10 to 15 days, due to the epidemic of influenza among her troops. *The allied nations did not make use of intensive gas warfare at that time.* A little, not very authentic, data is also at hand, indicating that workers in plants making war gases, mainly chlorin and its compounds, are more immune against infectious diseases than others in the same communities, and the same seems also to be indicated for workers in other chemical industries, where active gases pollute the atmosphere.

I quote from an article by Dr. F. Tweddell, Medical Record, Dec. 21, 1918. "If we examine the medical literature on the subject of phthisis, we soon discover that certain occupations are comparatively free from this curse and others are immune to it. On

page 98 of Fishberg's 'Pulmonary Tuberculosis' we find—'coal dust prevents the development of phthisis, and that miners are less subject to phthisis than all other occupied males.' " Dr. Tweddell suspected sulphurous acid gas to cause this immunity. Mr. H. J. Force, the chemist and engineer of tests of the D., L. & W. Railroad Company, became interested and made some analyses of mine gases and showed that in one mine the contents of sulphur dioxide was 17 parts per million, the air being taken shortly after a blast. "The amount of gas varied according to the number and irregularity of the blasts. Very powerful air fans are now used, which was not the case a few years ago. This accounts for the greater immunity in coal mines recorded by older writers. The presence of sulphur dioxide also explains why some cases of pertussis are benefited by visits to the mines." Many of us remember our grandmother's treatment for whooping cough and throat troubles, sending the children to coal gas works, to play in that polluted antiseptic atmosphere. Many cases—"miracles of medicine"—could be cited, to show how dependent present day medicine is on chemistry, its products and processes, and that a reconstruction in medicine and its teachings must tend to be along chemical lines.

A chemical influence in the reconstruction of teaching some underlying principles of law can also be anticipated, if only so far as to have expert testimony confine itself to actual facts, instead of being "precedents" based on scientific fancies and follies of the legal profession.

An inoculation of some chemistry into theology is also not out of place, especially in calling attention to the fact that the right way of living, the use of certain foods, and the abstaining from others, and certain religious sanitary laws, are based on chemical facts.

Agriculture, production, distribution and conservation of the products of the soil, is strictly a chemical consideration, and we should be active in solving the many agricultural problems that our reconstruction program will have to consider. We never again should become as extravagant and as selective in the use of our food products as we were before the war. The economic principles we were taught and practiced during the past two years should remain a part of our national custom, and should be daily habits. There was no hardship on any sane man, woman or child when we were restricted to two pounds of sugar per month. Four pounds of sugar per month will satisfy the most fastidious sweet tooth, and a return

to about 90 pounds per capita per year will again be wilful waste. We got along very well when using a greater amount of cereals, rice, corn meal, home-grown vegetables and green stuffs, more milk and cheese, and lesser amounts of meats, and all this should be continued. All these possible habits, help the solution of our agricultural reconstruction problem which is the foundation and the keystone of the whole edifice. The government has recognized the necessity of stabilizing our agricultural industries, through guarantee of minimum price for crops grown during 1919. We need only consider one real chemical industry to show the chemist's interest and place as to agriculture.

Before the war we depended on foreign nations for the greatest part of our nitrogen and potash fertilizers. We had phosphoric acid in form of a natural phosphate rock. This natural resource, a natural raw material, we exported to a very large amount, shipping it as ballast from Southern ports. We took part of it back, after the phosphoric acid had been made available, paying a high price for this simple chemical transmutation. We did use part of this phosphate rock ourselves, but we never exported any phosphate fertilizers, except in the form of natural rock-raw material.

As to nitrogen fertilizers, we actually paid tribute to foreign nations, and furnished the dividends for the British nitre trust. It is true we used our home made barnyard manure, and that no restrictions were placed on our cattle, preventing them from fertilizing the lands they grazed over. Our main nitrogen fertilizers came from CHILE or as guano, often after having crossed the ocean twice, with stop-overs at Hamburg, or Bremen or English or Dutch ports.

Potash salts we had none except those imported. We used many potash salts in industries and in our laboratories, which we have since replaced with sodium salts. This unnecessary use of potassium compounds was fostered through the propaganda of the German Alkali Trust. To-day we are home producers of potash salts, and what are we going to be in the near future? Are we going to construct a program that will enable these home industries to continue or are we again going to be potash dependents?

We can anticipate a surplus manufacture of nitrogen and potash fertilizers and other similar products, and we must develop a system that will take care of these industries. We cannot kill off the development of our potash deposits, and potash kelp industry,

nor should our potash recovery in steel mills and cement plants be given up. We must under all conditions utilize as much as possible of their outputs at home. While our steel and cement industries will live and prosper without a recovery of potash salts, from their flue gases, we cannot allow them to waste these products.

Nothing definite can to-day be stated as to our natural potash deposits as they are still in the initial stage of development. The kelp potash industry is undergoing a radical change, and its potash is becoming a by-product, the main products being those obtained from "wood"-distillation and iodine recovery. Our nitrogen-fixation plants, will have to compete with the by-product coke industry and the gas house nitrogen plants.

We must bear in mind that these nitrogen and potash plants give us really NEW sources of supply, not available, commercially non-existing before the war. We have found by the experience of the past four years that with a lesser consumption of potash and nitrogen, we obtain as good yields per acre as with the greater amounts formerly used. We have substituted soda salts for potash salts in industries and laboratories.

Our production therefore is excess over pre-war consumption, and we have substituted our own products for those we formerly imported. We must look for a greater production right along and we must enlarge our home consumption to take care of our own products of manufacture. We can do this by continuing our yard and vacant lot farms, by building new roads, using the rights of way for planting berry bushes and fruit trees, making them both ornamental and useful. We cannot expect any export business as our lesser imports, perhaps none at all, will increase available stocks in foreign countries, not considering that our "export" of manufactured product would have to compete with natural products, always cheaper. The nitrogen products from our government nitrogen-fixation plants are to be taken care of by the Nitrate Division, through the Department of Agriculture, who expect to sell during 1919 about 300,000 tons of nitrate of soda to farmers, at cost price, on board of cars, loading points. To what extent this will be a permanent policy of the government, I do not know.

Twenty-five years ago we imported large amounts of beet sugar, producing very little ourselves. In 1913, before the war, our imports were so small that the customs received did not pay the expenses of collection.

With a proper reconstruction program, our fertilizing industries, nitrogen and potash ingredients, can be in a similar position, be free from importations. The proper protection to our nitrogen industries, has direct bearing on our dye industry, as its source of raw materials comes from the same place, coal-tar and coke industries. In 1917 we manufactured an excess of dyes over our American needs, and we exported U. S. dyes of the class formerly imported to the value of \$11,709,287, exceeding in value our pre-war importations, although we did not reach our former imports in tonnage nor in varieties of colors. The 1918 value for dyes exported is given at \$16,921,288. Total amount of dyes made in the U. S. for 1917 is valued at \$57,639,901 (Census of Dyes and Coal Tar Chemical, Information Series No. 6, U. S. Tariff Commission & Supplement of December, 1918).

We can greatly increase our consumption of fertilizers if we will take to heart and follow the posthumous words of our great departed leader of humanity, Colonel Theodore Roosevelt, whose loss we all mourn, and who in his last editorial tells us:—"We should spend hundreds of millions of dollars reclaiming land for the returning soldiers and arranging labor bureaus so that he MAY be CERTAIN to have EVERY CHANCE to work." (Metropolitan Magazine, February, 1919.) Don't forget that Roosevelt left us this inheritance, that WE must do this, WE must give our boys this CHANCE.

Secretary Lane on Jan. 10th, 1919, embodied this suggestion of Roosevelt's in his informal recommendation to members of congress, in an appeal to gain farms for soldiers, asking for immediate consideration of the interior department's request for \$100,000,000, for the reclamation and occupation of 215,000,000 acres of tillable soil, in this country by returned soldiers.

The plan of the department will not only provide labor for thousands of men discharged from the military service, Secretary Lane said, but will greatly increase the resources of the nation. Briefly the program contemplates that discharged soldiers be employed at current wages on vast reclamation schemes in many states, and that they be permitted later to select a section of the reclaimed land for farming purposes, the government furnishing money to pay for the cost of development. This money, together with the full cost of the land and interest, would later be returned to the government in time.

"The project will not cost the government a penny," Secretary

Lane said. "Full payment for the land will be made within forty years."

While such work will increase the resources of the nation, it will also make a market for the nation's output of its nitrogen fertilizers. The government could use its own fertilizer in its reclamation project, taking it out of the competitive market. A reclamation of 200,000,000 acres would only require three pounds of nitrate per acre to take care of the total contemplated capacities of the government *nitrogen* fixation plants.

The industrial chemist must not forget that to-day we are perhaps the only credit nation in the world. We cannot expect to export products that we formerly imported, without helping to seriously affect trade balances, especially if at the same time we curtail our imports, through home manufacture. To maintain a necessary equilibrium in trade we must buy and cannot only sell, we must create liabilities to make good our assets. In all cases we will have to meet strong competition from our former war allies, our present friendly trade-enemies, who are to-day ignoring as far as they can our agricultural products, going to the Southern Hemisphere, Australia, the Far East and Africa for wheat, sugar, meats, leather, wool, cotton and other products of the soil.

We need have little fear of the former label "Made in Germany or in Austria" as that is a thing of the past in our country for a long time to come, but we are likely to bump into it hard in other countries.

To uphold our agricultural industries and those depending thereon, we must have protection, the proper financial assistance, a correct government control, regulation or ownership, at least a partial government partnership in industry, with or without subsidies. We must look to our own home market for our greatest demand and we must protect this, so as to hold it absolutely against all outsiders, and with it we must have a fair return to invested labor and capital. Under no condition can we allow our country to become a dumping ground for any foreign commodity, notwithstanding that the Webb-Pomerene Act allows us to do to others what we don't want them to do to us.

These requirements hold good for many chemical commodities, products from our glass, china, porcelain, clay and ceramic industries; it holds good for our coal-tar industries, dyes, colors, medical preparations, flavors, perfumes, solvents; it does not differ for

our food, fuel, petroleum, rubber, wood, textile or paper industries; it applies to our metal and alloy industries, in fact applies to every industry where chemistry is or can be involved. It applies to every industry whose products we formerly imported, and to all products for which we have found a suitable U. S. substitute.

It will not be many months before the devastated territory of France and Belgium will be rehabilitated and be again productive. America is helping not alone with food and money, but actually, rebuilding many industrial concerns on American foundations and according to American methods. What the American Army and Navy did in France is bearing fruit among the people of France and Belgium, and they have learned a lesson through observation. They see before them the marvelous picture of a community of about $2\frac{1}{2}$ million people created within 18 months, everything, people and supplies, brought 3000 miles, all ready for any "fight, fun or frolic"—and they did their share of the fighting. Future history will designate this work of our army and navy (and much of it was chemical) as the eighth wonder of the world, greater than the combined seven wonders of past history. These American methods of doing things are incorporated in the rehabilitation schemes of those countries, and their application will greatly shorten the time of recovery, bring them so much more quickly into a productive stage, and so much sooner into the world's markets and into competition with all their war allies.

While many old and historic monuments have been destroyed and are gone, as their halo of antiquity cannot be restored, they will be rebuilt and be shining beacons, demonstrating American mechanical engineering and chemical ingenuity and efficiency.

American steam shovels, portable saw mills, traction engines and many chemical reclamation tools are used in the French and Belgian reconstruction programs, which call for the extension of canals, new water and roadways, reforestation, and every other means to make their lands more productive and fitter places to live in, all agricultural improvements.

This has been a chemical war and should be a chemical restoration. We chemists cannot again be given places on the last row of the top gallery, in this world's show. We have been actors, in the spot light, holding the center of the stage. We have made good and can do so again, and if we are now pushed aside, it is our own fault. We are to-day strong and our existence is recognized, and we stand

where we stood five years ago—"The chemists of the United States have the brains and the ability and the gumption to make it, not 'Made in America' but 'MADE IN THE U. S.' All the chemists in the United States need to-day and all they 'AGAIN' ask for is the opportunity, fair play and an open field, not fenced in with adverse legislation." (E. G. 1914—this Institute.)

We now have the opportunity and can do our part in seeing that chemical industry takes care of every disabled soldier or sailor. That chemical industry allows every one of our returning fighting boys to return to his pre-war activities. We have the chance to do our part in the reconstruction of our educational systems. We must be an active force in solving problems as to health and social economic conditions. We must be a strong factor in the development of our agricultural interests, and the industries depending thereon. We must enforce our views for the protection of all new and newly developed chemical industries. We must exert ourselves in regard to conservation and utilization of our raw materials and our natural resources, and in the production and distribution of our manufactured products. We must become a vital part in a *real chemical reconstruction program*.

DISCUSSION

The PRESIDENT: We have quite a little time available now for the discussion of these papers and perhaps the development of some definite concrete proposition if any one has that to suggest. Does any one here wish to add to the discussion which has already taken place?

The SECRETARY: Mr. President, there is one point that I might mention which Dr. Gudeman spoke of, and that is the shipping of our phosphates to Europe in the raw state and bringing them back in the finished state. It just happened that I spoke to one of the chemists of a large fertilizer company who said that they are now shipping large quantities of the treated phosphate, super-phosphate to Europe, Belgium and France for the devastated regions, and that this is becoming a rather large part of the export business of that particular concern, together with the nitrogen products, that is, the tankage, and they have the potash abroad so that this American company is shipping the treated phosphate and the nitrogen products, including sulphate of ammonia to Europe where they add the potash for the finished fertilizer.

Dr. GUDEMAN: That is just lately, the last month or two.

The SECRETARY: The last week, he told me.

Dr. GUDEMAN: I know it was only within the last month or two because conditions are not the same, the same pre-war conditions do not exist to-day, and what we have got to do is *to keep that up*.

Mr. PETERKIN: I should like to comment on your statement, that high wages usually mean an increased capacity. That is a generalization which has not been borne out during the past war period, when higher wages than ever before have been paid and the per capita production in my opinion and in my experience has been much lower than in pre-war days. I think it would be correct to say that when the wages in any particular plant or possibly any particular industry are higher than the average, there is a tendency to greater production. The stimulation is lacking when the high remuneration and the greater amount of luxury which the working men are able to enjoy becomes general. It means a very real, intrinsic, increased cost of production which is not compensated by greater efficiency. I think that is a condition we have to face in the future.

Another point which I would like to comment on is the present business situation. At the present time there is a period of stagnation one of the causes for which is a very great uncertainty with reference to prices. There is a determination on every hand to hold up prices. The President has given his conviction that prices will stay on very high level for many years to come. I think that so far as prices represent an intrinsic increase in cost that that will be true. Labor will undoubtedly claim a greater share of the profits than heretofore. But the present situation is brought about to some extent by the hope that we shall continue to realize the very much greater margin of profit that we were able to realize before the war. In so far as the maintenance of prices is artificial, it is very detrimental to the industry. The tendency on all sides is to try to realize a wide margin of profit and to realize profits on large inventories which, although they have been written down, we still hope possibly to make good.

One of the big differences between German practice and American and English practice, or rather American and English tendency as compared with German tendency is the very much greater openness with which the work within individual companies is done and the very much greater openness between even competing companies. Secrecy is not a policy in this country usually in manufacturing

concerns. We try to get away from it but we can't. We are prevented from getting away from it in many instances by the very, very grave defects of the patent situation. As the patent matter is to-day you can get a patent on anything. The patent really grants you no protection unless you are in a financial position to protect yourself. I think that both the granting of patents and the protection which a patent affords need a very great deal of attention and improvement.

The PRESIDENT: Is there any further discussion?

The SECRETARY: Mr. President, there is one point that it seems to me has not been brought out, and I would like to say just a word on it. I do not know whether I have the right view of the situation or not, but just at present there is a slackening in orders and business, and there is also a condition by which chemists are seeking employment without finding it. The situation really seems rather hopeless to some chemists who are looking for employment, I happen to know a good many and they come to me for various reasons. On the industrial side the situation is that orders are not coming in and plants are hesitating or companies are hesitating to go on with the work. Now that is the situation on one side. On the other side—I think this is true, I may be mistaken, but this is the way it looks to me—that there is a great need of continuing the manufacture of products because there is a very great shortage in a great many lines. There is no question but that the manufacture of many articles which were used in peace has been held up on account of the war and stocks are very low and yet orders are not coming in. It is also true that there is a great need for the services of chemists in the United States. Dr. Matos brought that out very forcibly, and according to his statement it will take from three to five years to find out for instance what the cost of the production of certain dyes is and the dye which is he selling for \$20 to-day must be brought down to a much lower figure. The only way it can be done is by chemical work. It appears to me that the difficulty is entirely psychological or largely psychological. We are facing to-day the condition which faces the country very often when it gets into what we call a panic. Nobody trusts the situation and nobody knows what is going to happen in the future and nobody has the confidence to go ahead. I think it is the same way to-day, if we sit down and analyze the situation, and ask what are the needs, we will come to the conclusion there is need of a lot of manufacturing and a lot of ordering

and there is need of a lot of chemical service, but nobody wants to go ahead. Everybody is afraid to go ahead. It is a psychological difficulty. What is the remedy?

I do not know whether bringing out the difficulty will help us at all or not. I do not know whether this convention will go away with the right thought. This is a rather large body of men. I believe it is the largest attendance that we have had at any meeting on the opening day, both morning and afternoon. If we go away from this meeting with a feeling of confidence and a feeling that the future is assured, and we are ready to go back and say that the future is assured if we just go ahead, we will have accomplished something. There are some men in the industries, and you all know such men, who without any very definite reasons are always saying, "Oh, come on. Let us do it." You fear those men sometimes, you are afraid they will run away with things. They are men who get results, as far as I have observed. They are the men who have the spirit and the optimism and the feeling that it can be done and the man that feels it can be done will pull a lot of men with him, and they will all go ahead and will all do something. That is the way, it seems to me, we ought to feel. I do not know of any reason why we should not feel that way. I would like to know if there is such a feeling and I would like to know if there is any real reason for the apparent stagnation at this time.

On the question of wages and prices, I think our president has rendered us a real service if his point of view is correct and if it is accepted. If it is true that wages are going to remain essentially at their present level, if prices are going to remain at their present level for at least a reasonable time to come it seems to me that would remove two main causes why we need not stop. The only reason for stagnation, as far as I can see, is because everybody thinks that prices are going to fall, prices of material and prices of labor. Well, if the price of material and the price of labor is going to stay about where it is now, even for the next year, there is no reason why manufacturing should not go ahead. I would like to hear some opinions on this, whether my analysis of the situation is right or not.

The PRESIDENT: Let me say just one word. Undoubtedly in certain industries there has been a surplus of production. Benzol has been produced for war purposes. Toluol and metals have been produced, surplus stocks have been created temporarily. Those stocks will have to be sold and a drop in prices will follow, but that

has nothing to do with what is going to happen after those stocks are marketed.

There you have two distinct points of view. I, myself, as I have already stated, favor the view expressed by Mr. Vanderlip. I may be wrong, except that it has one very distinct advantage. It has the advantage of optimism, if you think that is an advantage. I certainly do. There was a gentleman here who was going to speak.

Dr. KELLOGG: I have hesitated about entering into the discussion because I wanted it on broader lines than our personal experiences, but there are two or three points that have occurred to me since our Secretary spoke or while he was speaking, as to the reason for some of this apparent stagnation in business, and if I am going to say anything that I know it must be from my own personal experience. We are large users, fairly large users of chrome ore for instance. Now the Bureau of Mines stimulated the chrome ore production in California feeling there was going to be a great shortage. The war trade board, or rather, the Bureau of Mines, sent men to California and got men to get out chrome ore. They obtained loans for them at the bank on the strength of what they were going to get for this chrome ore, and on the assurance of the Shipping Board that they would allow none to be brought into the country because they needed the ships. On the contrary the Shipping Board allowed it brought into the country right along whenever there was a ship over there available. Now we have gone to Washington and the other day Secretary Lane said that these men had to be relieved in California that had chrome ore and the moment the imports were stopped the California people jumped the price up from \$30 to \$40 and even to \$100 a ton, and we paid it and loaded up with \$100 a ton ore. Now the Bureau of Mines is using its influence to compel the users of chrome ore to use up these stocks in California at \$100 a ton, Secretary Lane threatening that he would forbid importations until it was used up. Now how are we going to go ahead and know what our prices are going to be? How are we going to expect people to make contracts with us this year on the present basis when they do not know what is going to turn up? We do not know what is going to turn up. We are also users of potash. We have a situation where we are paying from \$300 to \$325 a ton. Mr. Hurley of the Shipping Board announces that he is going to send over 500,000 or 600,000 tons of potash, that the shipping is available. Immediately the men in this country who have been able to produce potash besiege Wash-

ington with telegrams and there is a strong influence down there by the Bureau of Mines and others to prevent this potash being brought into the country until the producers in this country are able to unload all their stocks and to allow them to go on doing business to get \$300 a ton for potash which we bought before the war at \$15 a ton. Now there is only a fraction of the needs of the country produced at the present time in potash. I am not saying that at some time they will not be able to produce what is needed, but at the present time it is not being done and they are even construing it in Washington that it is trading with the enemy because they say while Alsace is in possession of the French that is technically German territory and therefore Mr. Hurley has no business to send Alsatian potash over here. They are trying to hold this thing off if they can for a month or two because if they hold off that long the potash will get over here too late to be of any use to the fertilizer people for this year, all to benefit a few people in this country who have a little money invested in this thing. The Government then might better pay those people for their losses, they might better pay the chrome ore people for their losses than to allow a few selfish interstate to stand in the way of the general prosperity of this country.

The same thing also applies to other commodities. The Government for instance is regulating wood alcohol, of which we are users. They have fixed the price. They have not let go yet. They are still holding on to it because there are some people who have a little larger stocks of wood alcohol than they should have and they are trying to allocate it between the different industries so that those men won't lose a little money on this and they are standing right in the way of business in so many different ways.

Now these are all little personal matters, but they are things that I happen to know about and they affect our company particularly and I assume possibly other people are affected in just the same way. How do you expect anybody to go ahead now and buy chlorate, for instance, or potash at the high prices of potash, \$325, when the possibility is that any time those things are coming down. People are not making contracts and are not doing business with the feeling that things are bound to come down. They are all living from hand to mouth. They are buying from hand to mouth, hoping for cheaper goods. I think that is one reason that business is quieting so much. Outside of this there is one other point which a previous speaker spoke of which I think of the greatest importance,

and that is, the matter of labor. Labor, Mr. Gompers says, is not going to allow any reduction in wages. Well, I think the manufacturers are making a great mistake and are very unpatriotic at this time if they reduce wages unless it is absolutely necessary until the cost of living should go down. I think it is wrong to begin at the wage end of it. They must wait until they are able to get a decent living at less money. But there is one thing, you do not hear Mr. Gompers or anyone else say anything about which is of the greatest importance, if the wages are going to stay up where they are, and that is the wage earners have got to be more efficient. They have got to give a fair day's work and that they are not doing. This idea that if you pay a man more wages you are going to get more output is a fallacy. You are going to get more output if your particular factory is paying above the scale commonly paid in the community, that is, if there is a surplus of labor you are going to get increased efficiency just to the extent that they can't go some place else and get a job just as good. There has got to be some educational work done in this country. Labor has got to understand that if wages are going to be kept up, if their style of living is going to be kept up they have got to be more efficient. They have got to do a fair day's work regardless of whether they are afraid of their job or not. There is a chance for a great deal of education along that line and Mr. Gompers would be doing labor more good if he would do a little talking along that line instead of making threats as to what they are going to do if wages are reduced. (Applause.)

Mr. DORSEY: I think there are a few other points which might be added to those already given by Dr. Olsen regarding the causes of general business depressions:

The first point is, that some of the enormous stocks of war materials on hand, which have a peace time value, are sufficiently large to provide our normal demands for probably a year, and in some cases, two years. If they are dumped on the market immediately, or without the knowledge and consent of industries interested, such concerns certainly are going to be paralyzed for the next few years.

The second factor is the fact that the Government owes thousands of small concerns more than their inherent value and that payments are extremely slow. Such companies cannot reconstruct, they cannot expand their business, nor can they lay plans for the future under such conditions.

The third point is the uncertainty which surrounds the tariff condition.

The fourth is the extreme high cost of labor with the low efficiency which goes with it.

Fifth is the good wholesome fear that most manufacturing institutions entertain for the Bolsheviki movement.

I think, as Dr. Olsen has said, that we ought to go away with a whole lot of confidence in ourselves. Most chemical engineers do have a lot of confidence. We ought to certainly go away with that. It does, however, seem to me that we ought to go away with a great deal more than this, we could go with a definite, crystallized plan of action to get in and help solve these problems.

MR. ANDREWS: Mr. President, it seems to me that it is very clear that the source of the uncertainty with regard to what the future carries is two-fold. It is partly economic in character and in part political. Now in weighing those two considerations against one another it is certainly very important that we should remember that in the end politics must bow to economic conditions. The economic question, therefore, is one that will control essentially, not perhaps the immediate situation, not the status of the immediate future, but will control the length of the period during which the high prices of things and of labor are likely to be maintained.

Now what really is the essence of the price problem? It seems to me that it is not very complicated but is essentially rather simple in character. The relation between the volume of money and the wealth of the world in things which that money represents is a fundamental relation. The reason why an increase in the volume of the medium of circulation, when the amount of real things which that money represents remains constant, the reason why an increase produces high prices is because it disturbs that relation. The relation, however, can be equally well disturbed by a reduction in the amount of those real objects of value if the volume of money remains the same. The destruction therefore, the enormous destruction of real things which results from war results in an inflation which is just as effective as an arbitrary increase in the medium of circulation would do, and this condition of inflation is bound to last until the destruction caused by the war is remedied and the total value of things becomes what it was before. Dollar bills are in the nature of certificates of stock behind which stand the material assets of the nations. In so far as you destroy those assets you diminish the value

of the certificates and reduce their purchasing power. Now it appears to be tolerably certain that the enormous destruction which the concentration of destructive activities of many nations for several years has produced, will require more than an equal period to remedy. It will be, it seems to me, at a very moderate estimate, at least five years before that disturbance of balance between total money of the world and total material wealth of the world is restored. We can look forward to a substantial maintenance of the present standard of prices for a period of at least five years. The labor question I believe will at the end of that time take care of itself, but not without a struggle. We have to anticipate a disturbance of that kind, but not at present. How can there be an upheaval when a material reduction of price is, for the reasons that I have suggested, apparently impossible. With regard to the inefficiency of labor, which according to my observation is an undoubted fact, I entirely agree with the last three speakers. It is a matter of public morals. It is just as important a matter for us all to take our part in an educational campaign on that subject as in the past it has been a moral duty with us to subscribe to the Liberty Loans. (Applause.)

Mr. CONNER: Mr. President, in view of the situation as many recognize it I believe that all the speakers have put forth the idea here that there is a stagnation in business, that every one fears to go ahead with his or their proposition, that all manufacturers rather hesitate to enlarge their business or carry out operations and lines that they have just started to develop. This organization is primarily an organization of analysts, I think the majority of the organizations of chemists of chemical engineers are, and the one thing that is uppermost in their mental processes is the process of analysis. If that is the case and we recognize the situation to-day as one of hesitation or stagnation or fear, it seems to me that with this in mind it would be well for us to analyze the situation and pick out from our own fields of endeavor some particular feature, some particular line of manufacture, some particular product, and put our shoulder to the wheel and try to push that particular thing, put some pep into it. The men in the plant all look to the chemical engineer as a man for some guidance. I think that the chemical engineer in the plant is recognized as the man who rather leads the way to some extent, and if that is the case if we go back to our particular lines of business from this meeting with the idea that we are going to do our share and not allow business to fall down, to drag, just put a little

pep into it, a little kick, pick out the think that is to our minds the most probable thing that we can do something toward putting over, we will accomplish something at this meeting.

Mr. NEWMAN: Mr. President, in regard to the enormous stocks of materials that the Government is carrying and they may carry for some time, it seems to me it would help the situation a great deal for all of us if we know just how much of each chemical material there was on hand that the Government is holding, and as soon as possible what they are going to do with it, and if it is to be sold out fast, if it is to be sold, then each manufacturer can judge for himself what he can do. It seems to me that a resolution might be brought up later on in the meeting to that effect to let us know what they are going to do.

Dr. GUDEMAN: Mr. Chairman, in answer to the last gentleman, there does not seem to be exact knowledge of the extent of such property, but the Government started in on the 1st of January to take a complete inventory of everything that the Government owned on the 1st of January. It may take six months to find out what they owned on the 1st of January, but that inventory is being made now. From the figures given to me not less than two hundred people started out of Washington about the 28th of December, I don't know the exact number, to make this inventory of the army and navy's supplies. I believe that this meeting should take some definite action. We have before us now a concrete example to work by. Previous to the war the importations of dyes were valued at about \$10,000,000. Let us consider that at the present time those dyes could be replaced from abroad at \$20,000,000, double the pre-war price, adding to this the proposed new duty, it will approximate in round figures \$30,000,000. Now the output of dyes in the United States during 1917 was approximately \$58,000,000. I believe the figures for 1918 will exceed these by \$10,000,000. The dye manufacturer knows where he is at. Taking the value of dyes during 1917 at \$58,000,000 and the pre-war industry, at present valuation at \$30,000,000, the manufacturer knows that there is going to be a drop in valuation of about \$25,000,000 for dyes consumed in this country, to which must be added about \$10,000,000 value of dyes exported. He has some basis for figuring the value and magnitude of the prospective dye industry.

Now if other manufacturing chemical industries will get together, and go to the Tariff Commission, and get the Commission to pick

out a man of standing in their industry as that which Professor Jones has in chemical coal-tar industries, or let us say in the dye industry (he has only taken up that branch before us, and he could have taken up others, just as well, if he had had the time), those specific industries very soon will know the conditions they have to meet. They would know what their tariff protection should be and they could adjust themselves accordingly, or get out of the business. The dye manufacturers know that if we are going to give up the manufacture of the dyes we formerly imported, that this will mean a \$30,000,000 business done in imported dyes, and so much less in domestic dyes. They know what the total value of the market is that they can look for, and they are adjusting themselves accordingly, and are going ahead because they know the protection the Government is going to give them, or at least know what to expect, and without this protection our dye industry cannot exist. If other industries would go to Washington and have experts put in to do the work that the Tariff Commission did for dyes (the Commission really didn't do it, Mr. Kelsey says they did a great deal, but actually Dr. Jones did it all for the Commission), those other industries would know where they stand. That is the only way to put those industries on a safe basis, so that they can manufacture and develop. They must know in advance what the conditions are that they have to meet, and as far as can be foreseen what the conditions will be, that they will have to meet. I believe we ought to have some resolution covering the wants of other industries, whether it be glass, steel or wood, in fact all other chemical manufactured products, especially those formerly imported, surveys, and recommendations as to proper tariff protection, same as has been worked out for the dye industry.

The SECRETARY: Mr. President, I want to move that a committee be appointed by the President to draft a resolution such as Dr. Gudeman suggests and also to draft resolutions covering the subject-matter of the discussion that we have had and present that resolution or those resolutions for discussion. I believe it will help a great deal to make our discussion concrete and make our influence felt. I don't think we should carry on this discussion and just go home with the enthusiasm that we have received here. I think it ought to be put down in carefully measured words. I would like to see that committee appointed at this session this afternoon and, if possible, in order to have a report made at the evening session to-night at eight o'clock when we come back again, so that we could

have something at least as a definite basis for discussion to-night. We will have an hour between eight o'clock and nine o'clock, because the local committee wants us to adjourn at nine o'clock for the smoker. They want us to break up at nine o'clock for a social time which they have prepared and I am sure we are all ready for it as we all want a good time and want to get acquainted with each other personally. That is one reason why we came here. If we could get five or six men who would give up their dinner and everything else between now and eight o'clock and get busy and put this into black and white, the rest of us at least can have a good time between now and then. I so move, Mr. President.

Dr. GUDEMAN: I second that motion, Mr. President. I just want to add that the Government you know has taken that view on the wheat production of this country, they have made a fixed price for the crop that is growing now, the winter wheat, and for the spring crop, setting a price of \$2.26 so that the wheat farmer knows where he is at, but the corn farmer with the price of corn around \$1.25 or \$1.40, does not know where he is at because Argentine corn is coming right into our country at 76 cents a bushel in Argentine, and about a dollar here.

The Government has stabilized the price of the 1919 wheat crop, and something of a similar nature should be done for the chemical manufacturers.

The PRESIDENT: You have heard this motion. I would like to make the suggestion that the motion be made as broad as possible, that a committee be appointed, if Dr. Olsen will allow me to state it, to consider the matters which have been discussed here to-day and to present a report of a resolution or resolutions or petitions in such form as they think best for consideration at a later meeting of the institute. Let it be broad without any specific narrowing down to anything, all the matters which we have discussed. I would like to make also the suggestion, if I may, that that be made a special order of business for Friday morning instead of to-night. I do not believe that that committee can do justice to the work by this evening.

The SECRETARY: I thought maybe, Mr. Chairman, that they might have a tentative report.

The PRESIDENT: If they have anything to report all right but report finally by Friday morning. You have heard this question. Do you wish to discuss it, or would you like to have the motion put?

Dr. GUDEMAN: I move that the President be a member of that committee.

The PRESIDENT: Well, he will consider himself *ex officio* a member, if you will kindly allow that. Those in favor of the motion will say "aye," contrary-minded "no." It is carried.

I know this was coming and I have been thinking about it. I sized up two hours ago that we would have to have a committee appointed and so I have made up a list here simply trying to represent the industries as far as possible, and I have appointed perhaps what you may think is a rather large committee, a committee of seven at least. I do not believe that committee is too large, however, considering the importance of the matter. I will appoint Dr. Gudeman, Dr. Toch, Dr. Matos, Dr. Hooker, Dr. Lihme, Dr. Dodge and Dr. Kellogg on that committee. That covers a great many different industries and that committee can get to work as soon as it can arrange to do so. I will ask Dr. Gudeman to act as Chairman of the Committee and to get them together.

Dr. GUDEMAN: Mr. President, I wish you would add Professor Jones' and Professor Parr's names to that committee.

The PRESIDENT: I would be very glad to add them, making that a committee of nine.

Dr. GUDEMAN: And you to act with the committee as the presiding officer.

The PRESIDENT: Well, I think it would be better to have Dr. Gudeman act as Chairman of the committee. Then he will present the report which I will have to receive here as President. If you don't mind we will do it that way but I will act with the committee. Is that appointment satisfactory? Are there any other suggestions that you think of? Would it be wise to make additions? That makes a committee of nine.

Dr. GUDEMAN: The Secretary is on that committee *ex officio* also, isn't he?

The PRESIDENT: Yes.

Mr. KELLOGG: I see a man gets into trouble if he opens his mouth, but there is one other matter that I think of very great importance and that is the matter of having an anti-dumping clause in our tariff. We had one that was very good, I believe, when the last tariff was enacted but at the last minute it was struck out. I believe that the Dominion of Canada has an anti-dumping clause which really works because I have helped several manufacturers over

there to work it. As I understand it, if goods are sold over there at a lower price than they are sold in this country, at the same time for the same kind of goods, all that is necessary is for someone over here to buy goods at that time and get the invoices for them and they are sent over there, all they have to do is to present those at Ottawa and they get—I don't know just what the adjustment is, but I know it is quite satisfactory and it stops it. It works. Several times I have gotten invoices for goods to help out a very good friend of mine over there, and I think that it is of the greatest importance because at the present time you can combine to export, you can fix your prices, but there is nothing to prevent any country—and I don't believe all your trouble is going to come from Germany either—there is nothing to prevent any country dumping similar goods over here at any price they please. They can buy your goods that you sell over there at this price and they can ship them right back here and sell them and take a loss and demoralize the American market. There is nothing at all to prevent it at the present time.

Mr. DILL: The question has been raised as to how far the efficiency of our men is increased by increase of wages. In connection with that I would like to ask if any here have had the same experience as our company has had in regard to allowing men to work overtime, and that is that if they work overtime at night or on Sundays they are perfectly satisfied to let their weekly earnings remain the same and for as much income as they have from their overtime they take a corresponding amount of time off their week. For example, if they work Sundays and are paid double time they feel that they can lay off for Monday and Tuesday and still have just as much in their pay envelope on Saturday night as they had before. So we have found by working the men overtime that we really do not get as much work done as if we let them stop at five o'clock. I would like to know if any of the others have had that same experience and if they have been successful in doing away with it in any way.

The PRESIDENT: I am afraid a remark which I made was a little bit misconstrued. I made the statement that high-priced labor is cheap labor. I venture to state that if I had a factory alongside of another factory, say, operated by Mr. Dill, and I paid my employes 25 cents a day more than he paid his, I would get the best workmen and he would get the poor workmen. That is what I mean by high-priced labor being cheap labor in the long run.

It is just exactly so among you chemists. If you look around and think about the ones you would hate most to compete with you will find that they are the ones that have the largest income. I don't fear the competition of the man whose income is less than mine. I fear the competition of the man whose income is greater than mine amongst chemists. That was the idea that I had. However, I do not want to interrupt the question which Mr. Dill asked as to the experience with regard to laborers in factories.

Mr. DILL: Perhaps I ought to explain that a little, Mr. President. The circumstances were these, that that situation did occur. Some of our neighbors paid 25 cents a day more than we did, but the period of that differential lasted about 24 hours so that the workmen did not flow from one plant to another.

The PRESIDENT: You mean you followed suit?

Mr. DILL: We met the ante very soon. We found, however, that although the men did not go from one plant to another that as the wages went up the percentage of absenteeism very largely increased. The men were apparently satisfied with their income and used the increased earnings simply to take a day or two off every week. The suggestion was made by some of our neighbors to put the overtime on a weekly basis, say, that instead of paying overtime, after having worked eight hours on any separate day, we should pay overtime only on the basis of hours in excess of forty-four hours a week or forty-eight hours a week. I have heard that suggestion made but I have never seen it tried out and I would like to know if any one here has actually tried that experiment.

Mr. PETERKIN: We had that difficulty and attempted to meet it but the outcome was not satisfactory. If I remember rightly we attempted to meet it not by putting it on a weekly basis but by refusing to pay the extra amount for overtime unless the man put in the average number of hours, the proper number of hours' work the other days; that is, we only paid the ordinary amount if he was present the rest of the week. The question of absenteeism has been very generally met in a great many works by a bonus which depended upon the man being punctual and prompt at his work every day in the week. I am not much in sympathy with the overtime question. I think it is a very difficult one and it is a good thing that it is so difficult to meet. I may say that the workmen did not accept our plan. It was not welcomed by the workmen. They kicked and we had to put the overtime back on the old basis. Disregard-

ing any absenteeism the mechanics with whom we tried it would not stand for it.

The PRESIDENT: I do not know whether I would dare to suggest that perhaps in some respects a great many of our chemical industries are new and that what might be true of the older chemical industries might not be as true of the newer chemical industries. In an old established industry the one thing that the manager tries above all other things to avoid is what they call labor turn-over. They want to keep the employes with them as long as possible and change them as seldom as possible. Now, during the last two years, there has been, of course, a great difficulty in that direction, but there has been a great deal of study given to that question. It is one that really deserves a great deal of attention—just how to avoid what they call labor turn-over. In some industries they have apparently solved it. They have solved it by welfare work, not merely by wages, but by having the right kind of foremen that will have the human interest of the employes so that if men are sick they look after them, if men get dissatisfied they have some means of expressing their dissatisfaction. However it may be, it is very evident that in every industry, to be carried on successfully, the change of labor ought to be avoided. Of course, if an employe works five days a week and then puts in one day or one night overtime and gets the equivalent of seven days' work, that is not very good business. You may have to meet such conditions as things are at present if you have them. Is there any further discussion of this topic?

I want to say that our committee met this afternoon and is meeting now. It is endeavoring to formulate resolutions which will be presented at our Friday meeting. The great difficulty that confronts the committee, and perhaps you can offer some suggestions to help it out, is making definite recommendations which will cure the troubles which were mentioned to-day. We had the benefit of what was stated by Dr. Jones in reference to the tariff commission and the dye industry. There are certain definite recommendations which the tariff commission has made, but the tariff commission has made no definite recommendation as yet with regard to an anti-dumping clause and could we word one that would be thoroughly satisfactory to us or shall we simply take it on a broad academic proposition? Now, on the other hand, what can we recommend or what have you to suggest that we should recommend

with regard to the accumulation of chemical stocks manufactured in excess of what would be commercially needed. I do not know what our committee could recommend and put in the form of a resolution. If any one has any suggestion as to what could be recommended to meet a condition of that kind it would be very desirable to have that recommendation brought out here at this meeting so that the committee can consider it. In some cases these stocks have gotten to be very large and have been paid for at high prices possibly. How are they going to be turned back without breaking the market?

The SECRETARY: I would like to say one word, Mr. Chairman, on the labor question. I do not know whether this is pertinent or not but when you talk about a laborer or a worker in a factory who will put in overtime and increase his wages and then take one or two days a week off the thought comes to me that that is nothing more than human nature, and it is exactly what every man in this room to-night would do. There is not a man in this room to-night that does not endeavor to make as much money as he can in as short a time as he can and get as much vacation as he can. We justify it and we do not blame ourselves, but if a workman does that, then we say he is stopping the industry. If we look at the human side of this matter and if we put ourselves in the position of a workman and know how he thinks, perhaps we can solve the question a good deal better and perhaps we can get more influence with the workman if he knows that we stand by his side and say, "Yes, I know that is what you want and that is what we all want, and I am with you and I want you to make as much money as you can."

Now there is one remedy that occurs to me, and that is this: Every man in this room to-night requires more money to live than the laborer requires or the mechanic requires. We could not live for the wages that we expect a workman to live on. Our necessities which have come with our education and our habits and our mode of life have made us need more money. Now it seems to me economically the mechanic or the workman will very soon move up, so far as his needs are concerned, to a point where he must have that additional money. As soon as you pay a man \$50 a week for two or three years he gets to the point where \$40 a week or \$30 a week is underpay and he says he can't live on it. He has developed habits for \$50 a week. The difficulty, as it appears to me, is that this increase of wages has been too sudden. We have had an abnormal

rise in the curve, rising too quickly and the workman has not been accustomed to the new conditions. It is the war that forced this overtime and these high wages to stimulate production, that is, so far as living conditions are concerned, and when living conditions have once caught up with your workman, when he has once acquired the habit for enough luxuries so that he will need that money he will do exactly what every man in this room will do. We will work provided we think that money is going to give us pleasure. Now when we get to a point where we have acquired enough money to give us a living so that we do not have to work, we will all quit working just as the workman does when he gets high wages.

Of course, there is the other side of the question, to endeavor to get the workman to co-operate in the success of the industry. I believe that is the important thing. I believe still further that we are allowing too much class feeling to come up in the United States of America. I believe that is a menace to our industrial organization; that it is up to us as technical men, if possible, to break through. Now, as I look at society, where I live, and the people I associate with, I have no connection and no contact at all with a certain class of society, and they have no connection with me in my work. A man in a plant, a chemical engineer, or any technical man in a plant, does come into contact with his workmen. There is contact there between the classes. Now I realize that the yellow journal has done us an awful lot of harm in fostering class feeling, and the more it is fostered and the wider the breach becomes the worse it is for us. It is Bolshevism in the embryo. As soon as we take the attitude that the workman must and should work six days a week, no matter what money he has, and we show that attitude, we are antagonizing him. He will see us, the so-called capitalistic class making money and loafing and that is what makes him feel sore and that is the trouble. Now if we come to that workman and say, that is all right, Jim, or John, I sympathize with you, I want you to make every cent you can make and I want you to live in as good condition as you can live, and I want you to go ahead and get a good home. If you can afford an auto, get it and take your family out, and encourage that fellow to go ahead in every way and spend his money, spend it for a good time, you will soon get to a point where that fellow is going to work six days in a week because he will acquire the necessity for having the money.

There are the two phases of the situation. One is to break

through, so far as we can, the class feeling and make the workman feel he is a part of society and that he is not one portion which is set off with entirely different human desires and human feelings; that he is human in every respect and that he is to be treated as the man who must work six days in the week, no matter what he gets. We, on the other side, can accumulate all we can, take our vacations and enjoy ourselves when we have accumulated enough so we can do it.

Now that may be just a little revolutionary, but it seems to me that is the human side of this discussion.

Dr. WESSON: I would like to ask every chemist in this room to stand who keeps himself down to less than 44 hours a week.

Mr. DILL: Mr. President, I do not want to be on my feet all the time, but in regard to that other subject you spoke of a moment ago, just to get it before the meeting in such a shape that we can discuss it, I would like to move you that we recommend that the work done by the War Industries Board be continued to the extent that the Government shall supervise the allocation of these stocks of raw materials that have been accumulated and are now in the hands of the Government.

(Motion seconded.)

The PRESIDENT: You have heard the motion that the War Industries Board be continued for the purpose of allocating various stocks of materials which are in the hands of the Government so that they can be distributed with the least harm. I would like to have the discussion on this motion but I would like to hold off the vote, if I may suggest that, so that the committee can have the benefit of incorporating the idea as developed from the discussion, in resolutions which they are preparing. If you force the motion, of course, it is perfectly proper. I simply make that as a suggestion. Now, is there some one who can tell us whether the War Industries Board has not passed out of existence?

Mr. DILL: That is the object of the motion, Mr. President, because I think it went out of existence at midnight on New Year's Day.

The PRESIDENT: I think it has gone out of existence, so of course your motion would be that something corresponding to the War Industries Board be constituted to do this work.

Mr. DILL: Yes, sir.

Dr. JONES: I think there is a Government organization already

doing it under the direction of Assistant Secretary of War Crowell. I am not directly informed, but I think that is true.

Mr. BRAGG: I think Mr. Jones is mistaken about that, because I know in two or three instances neither the War Industries Board nor the War Trade Board nor any other board is taking care of that point. Did you refer to stocks of chemicals or did you include other things?

Dr. JONES: Everything.

Mr. BRAGG: You and I won't discuss that, but I would like to say this, Mr. President, I think that that is a very inclusive motion. I think it covers a great deal more territory than we realize for the moment because I happen to know, for example, that the copper producers are working on that point. I know that the Government is not doing very much on it. For example, I might say this to you, that I know there is about 250,000,000 pounds of brass scrap which is now on the market which has driven the price of copper down from 26 cents to about 20 cents in less than thirty days, and if it is true that the Government is taking any steps to allocate these tremendous stocks, not only waste material which can be recovered, but new materials, they are keeping it pretty well concealed. It may be Mr. Jones knows that in some other lines they are taking care of that thing. I am not objecting to Mr. Dill's motion, but I am saying that we ought to realize how inclusive that is and what an awful problem we are suggesting to have solved here in a very few minutes. The thing is colossal and I do not know that anybody could suggest anything better than we can or any more appropriately than we can that it should be tackled in some systematic manner by the Government. I think that is true, but we must realize that the thing is so colossal that hardly any group of men in any few minutes could really get anywhere with it. Personally, as I said when I started, I know of some instances where there is no attempt being made to do that and it is approaching disaster in some instances now and to that extent I think the motion is a good one.

Dr. ANDREWS: I would like to ask whether the wording of that motion is not to a certain extent ambiguous in the phrase which refers to stocks in the hands of the Government. The intention of the motion, I take it, is to cover not only the stocks that are actually now Government property, but the stocks, which are still in the hands of private corporations, contracted for by the Government but which have not yet been delivered and losses on which

would ultimately have to be paid by the Government. Isn't it just as important to so word the motion as to cover these stocks as well as those that are actually in the possession of the United States?

Mr. MILLER: I understand just very recently that the Government is still allocating preservative oils for wood preservation. If there is some one from the Barrett Company here who can tell us definitely about that we may be able to decide that there is somebody in the Government service still doing that kind of work. I just heard that last week.

The PRESIDENT: Can any one answer that question? I noticed in some discussion in either the Senate or the House of Representatives, a motion was made that materials in the hands of the War Department be turned over to the Agricultural Department and be used for motor reconstruction. This information was brought out. They were selling horses at very low figures for which high prices were paid and this was being done at the various camps and so apparently there is a good deal of selling going on, and apparently going on in a great many different lines. The whole question, I am afraid, is a very complicated one, because, as Mr. Bragg has said, with regard to copper, that has been handled probably in a different way from a great many chemicals. I happen to know that in the case of tin it was handled in a way in which the Government could not lose, but it may be that somebody else will lose. Who is going to lose I do not know. The price of tin in New York has been fixed by the tin committee at $72\frac{1}{2}$ cents and tin is selling at 50 cents in London. You cannot import and you cannot get a license to sell it. That proposition will probably be straightened out some time in the near future.

The whole proposition in Mr. Dill's motion is simply this, that in so far as the Government has power to do it, some power, some instrumentality should be established for the handling of such products as we are particularly interested in so that they will not be dumped upon the market, the market demoralized, and some system of allocation or distribution be provided that will not completely wreck the chemical industry. That is, as I take it, the substance of the motion, so far as it can be worded. If Mr. Dill will just not press the motion and let that motion be considered by the committee I think they can formulate something.

THE PRESENT STATUS OF NITROGEN FIXATION*

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Read at the Chicago Meeting, January 16, 1919

INTRODUCTION

Fixed nitrogen in some form is an essential constituent of the food of all the higher animal and vegetable organisms. Fixed nitrogen in the form of potassium and sodium nitrates has been of prime importance in warfare since gunpowder came into general use. The ammonia resulting from the destructive distillation of coal has been recovered and used in the chemical industry for more than a century. *Free* nitrogen forms nearly 80% of the air we breathe, but in the free form it can neither be utilized by the bodily mechanism nor in explosives nor fertilizers. The chemist has known for many years how to convert this inert gas into other compounds in his laboratory; but it is only within the last twenty years that the fixation of nitrogen has been recognized as an industrial as well as a scientific problem, and only within the last five years that its importance has become generally recognized.

Sir William Crookes in 1898 called attention to the diminishing supply of Chilean nitrate, and the need of replacing it with a synthetic product if the world was not to be confronted with possible starvation as a result of shortage of nitrogen fertilizers. But although this stimulated interest and may almost serve as a date for the commencement of industrial research on nitrogen fixation, it was ultimately war and not peace which caused the rapid development of the processes for fixation of atmospheric nitrogen. One of the proofs of Germany's coldblooded calculation is found in the subsidized development of the nitrogen fixation industry. The sodium nitrate vitally necessary for explosives was found only in Chile, and its supply would almost certainly be cut off in a war with a first-class naval power.

* Published by permission of the Chief of Ordnance.

† Chief, Research Technical Section, Nitrate Division, Ordnance Department.

The German Government did not declare war until it had the Haber, Ostwald and Cyanamide processes developed to the point where it knew it could become independent of Chilian supplies.

Almost all of the military explosives, whether used as propellants or as bursting charges, contain large percentages of the nitrate group. If this is to be supplied from sodium nitrate, there will be needed nearly 2 pounds of sodium nitrate for each pound of explosive, as shown somewhat more in detail in the following table:

<i>Explosive</i>	<i>Nitrate Factor</i>
Smokeless powder	1.70
Trinitro toluol	1.70
Picric acid	2.50
Miscellaneous high explosives	1.50

Ammonium nitrate, while not itself an explosive under ordinary conditions, becomes, when mixed with a portion of its weight of TNT, the very satisfactory high explosive amatol, important as a bursting charge for shells. Ammonium nitrate is the richest of all explosives in nitrogen.

SUMMARY OF FIXATION PROCESSES

It is the first step in nitrogen fixation which is the most difficult. The nitrogen molecule as it exists in the air is very inert and becomes active only at high temperatures or in the presence of some activating substance. The processes may be classified as follows:

1. *The arc process* for the direct combination of the nitrogen and oxygen of the air to form nitric oxide which subsequently by oxidation with air and combination with water forms nitric acid of approximately 35% concentration. There is required about 10.5 H.P. years electrical energy per ton of nitrogen fixed as nitric acid per annum.

2. *The cyanamide process* involving:

(a) The production of calcium carbide through reaction between lime and coke in an electric furnace.

(b) The interaction of calcium carbide and pure nitrogen at a red heat to form calcium cyanamide.

(c) The decomposition of cyanamide by steam under pressure, to form ammonia.

(d) The oxidation of ammonia with air to form dilute nitric acid of approximately 50% concentration.

The power required by this process is approximately 2.5 H.P. years per ton of nitrogen converted to nitric acid per annum.

3. *Nitride Processes.* The best developed of these processes is that for making aluminium nitride from aluminium oxide, coke and nitrogen heated to a temperature of perhaps 1800° C. in an electric furnace. This process has not been developed far enough to show its ultimate power requirements, but it is approximately in the same class as the cyanamide process. The aluminium nitride after formation, may be decomposed with steam or dilute caustic solutions yielding ammonia and regenerating the alumina.

4. *The direct synthetic ammonia process*, usually called the Haber process, wherein pure nitrogen and hydrogen are made to combine in the presence of a catalyst, at temperatures which in commercial work have usually approximated 500° to 600° C. and under pressure of 100 atmospheres, or higher. The ammonia made by this process is then oxidized with air and converted to nitric acid. Electrical energy is not necessary for this process and the total power requirements are only about 0.5 H.P. year per ton of nitrogen fixed as nitric acid per annum.

5. *The cyanamide process*, wherein a mixture of sodium carbonate and coke with iron in small quantities, is heated in a stream of pure nitrogen to a temperature of approximately 1000° C., resulting in the formation of sodium cyanide. This furnace product may be decomposed with steam, yielding ammonia. Power requirements for this process are of the same order as for the Haber process.

It will be seen that all of the above processes, except the arc process, yield ammonia as their initial product. The arc process requires the greatest expenditure of electrical power, the cyanamide and nitride processes rank next, and the direct synthetic ammonia and the cyanide processes require only small amounts of power. In fact, these two latter processes do not necessarily require any electrical power, it being possible to carry out all the heating reactions without the use of electrical energy, although electrical heating may in some cases be more economical. If nitric acid is desired, the ammonia produced by these processes may be oxidized to nitric oxide by air, in the presence of a catalyst, usually platinum, working at 750° to 850° C. The nitric oxide resulting is oxidized by cooling, mixing with more air if necessary, and passing through towers, down which water or dilute nitric acid trickles. The resulting product is about 50% nitric acid. This oxidation process requires very little external

energy. It may be considered that the principal problem is to get atmospheric nitrogen into a combined form, and that the problem of converting the initial form of combined nitrogen into the final form is distinctly simpler and better elaborated.

NITROGEN FIXATION IN THE UNITED STATES

It was reserved for two Americans, Bradley and Lovejoy, to first place the fixation of nitrogen on an industrial scale in their plant at Niagara Falls, New York, in 1902. This historic attempt, though well conceived, failed largely because of the lack of sufficiently cheap electrical power at Niagara to allow the process to be carried to industrial success. Later developments were made mainly in Europe, largely because of the existence there of water power which could be used to generate cheap electrical power necessary for most of the nitrogen fixation processes.

The subject of nitrogen fixation in the United States had been studied by some of the larger corporations prior to the outbreak of the European War in 1914, but no commercial plant had been installed in this country, and only one plant had been actually installed in Canada, that of the American Cyanamide Company, at Niagara Falls, Ontario. The United States Army authorities were alive to the critical situation in which this country would be placed should it enter the war and its connections with Chile be interrupted; but no money for fixation was appropriated until the passage of the National Defense Act of June 3, 1916, which carried as its Section 124 (Nitrate Supply), an appropriation of \$20,000,000 to be placed at the disposal of the President for investigation of "the best, cheapest and most available means for the production of nitrate and other products for munitions of war and useful in the manufacture of fertilizers, and other useful products, by water power or any other power as is in his judgment the best and cheapest to use." This act also conferred on the President broad powers in the acquisition of processes and of land, and in the construction of plants and sale of product.

The question of nitrogen fixation with special reference to the use to which this money should be put was studied by several Nitrate Commissions, the first organized by the National Research Council, and the others by the Secretary of War; but retaining a considerable proportion of the original membership. Their conclusions and the

action recommended and taken up to August, 1917, have already been published.*

When this country declared war on Germany on April 6, 1917, no definite program had been approved and no further commercial developments on the manufacturing scale had taken place, although the American Nitrogen Products Company had established at La Grande, near Seattle, Washington, a small experimental arc process plant, which was producing sodium nitrite. On July 7, 1917, the Secretary of War on behalf of the President approved the recommendations of the Nitrate Supply Committee and directed that approximately \$3,900,000 be placed at the disposal of the Chief of Ordnance of the United States Army to carry out the recommendations of the Committee. The Ordnance Department instituted the Nitrate Division on July 25, 1917, with Colonel J. W. Joyes as Chief, to carry out the program of construction and research therein laid down, and to have charge of such other nitrogen fixation projects as should be committed to it.

The files of the Nitrate Division contain confidential reports received from the French and British governments, as well as the records of eighty-four special investigations that have been made in this country. The Nitrate Division corresponded with, and in most cases had personal interviews with every person or institution which it could learn were interested or had worked on nitrogen fixation. It is a great gratification to be able to record that with hardly an exception all of those individuals and firms placed their information at the disposal of the Government without reservation. They cheerfully allowed the Government to make any tests which it wished at their plants, and many of them went on with their work at their own expense at the request of the Government, in spite of the difficulties of conducting the work in war time, and in spite of their feeling that from their own standpoint they would rather have put their energies into other lines of work. Although the files of the Nitrate Division contain all these reports, it would be manifestly improper to disclose their content, or even to list the names of those who were working in this field without their permission. Perhaps some day a complete report may be written on this subject. For the present a brief summary must suffice.

* Journal Industrial and Engineering Chemistry, September, 1917, Vol. 9, No. 9, pp. 829-41.

UNITED STATES NITRATE PLANT NO. 1

The Nitrate Supply Committee,* on May 11, 1917, made among others, the following recommendations:

"The committee, appreciating the offer of the General Chemical Company, recommends:

1. That the Government enter into negotiations to acquire the rights to use the synthetic ammonia process of that company.

2. That contingent upon satisfactory arrangements with the General Chemical Co., out of the \$20,000,000 Nitrate Supply appropriation, such sum as may be needed, now estimated at \$3,000,000, be placed at the disposal of the War Department to be used in building a synthetic ammonia plant, employing the said process of the General Chemical Co., and of a capacity of 60,000 pounds of ammonia per 24-hour day, said plant to be located in a region where land, water, coal, and sulphuric acid are cheaply available, where good transportation facilities exist, and where the proposed new powder plant of the Government can be properly located. In the opinion of this committee all of these conditions just enumerated are best fulfilled by a location in southwest Virginia or contiguous region.

3. That out of the \$20,000,000 nitrate supply appropriation an amount now estimated at \$600,000 or as much as may be needed, be placed at the disposal of the War Department to be used in building a plant for the oxidation of ammonia to nitric acid and the concentration of nitric acid, of a capacity equivalent to 24,000 pounds of 100 per cent nitric acid in a 24-hour day, said plant to be located in the neighborhood of the aforesaid synthetic ammonia plant and the proposed new powder plant of the Government.

4. That the War Department proceed at the earliest practical date with the construction of the oxidation plant and contingent upon a satisfactory arrangement with the General Chemical Co., also with the synthetic ammonia plant, and that the Government give such priority orders as will secure from contractors prompt delivery of the materials and rapid construction of the structure and machinery needed for these plants."

* The full report of this committee, together with some other documents, is to be found in the *Journal of Industrial and Engineering Chemistry* for September, 1917, Vol. 9, No. 9, pp. 829-841.

This recommendation, having been approved by the Secretary of War on behalf of the President, constituted the first instructions to the Nitrate Division of the Ordnance Department. The plant built as a result of these instructions is known as United States Nitrate Plant No. 1, and is located at Sheffield, Alabama. This group is composed of four principal parts, the synthetic ammonia plant, the ammonia oxidation plant, the ammonium nitrate plant and the nitric acid concentration plant. The synthetic ammonia plant was built in accordance with the designs of the General Chemical Company, and the construction and initial operation were carried out with their active co-operation. It consists of three units, two each of rated capacity of 15,000 pounds of anhydrous ammonia per day, and one of capacity of 30,000 pounds per day. The many difficulties in obtaining equipment delayed the completion of this plant, and its first unit did not start into operation until September 15, 1918. As was to have been expected, there were numerous minor troubles in starting this new process, and its operation was still in a somewhat experimental state when the armistice was declared on November 11, 1918. No attempt has as yet been made to start the operation of more than one unit of the plant.

The ammonia oxidation plant was built to oxidize approximately one-half of the ammonia made in the synthetic process, it being the intention to have as the ultimate product of the plant, ammonium nitrate. The catalytic agent in this plant is a platinum gauze, and the converter is one designed by Captain G. A. Perley, of the Ordnance Department, after designs made initially by Dr. Charles L. Parsons of the Bureau of Mines, and Mr. Louis C. Jones of the Solvay Process Company, as the result of co-operative experiments made at the plant of the Solvay Process Company in Syracuse, New York. The oxidation towers and acid system were designed and installed by the Chemical Construction Company of Charlotte, N. C. This oxidation and acid plant has had relatively little opportunity to show its efficiency, and has never been operated up to capacity, but so far as has been operated, it has shown itself to be satisfactory. The ammonium nitrate plant follows a fairly standard design which has been worked out by various munition manufacturers, and although it has not had much continuous operation, it has worked entirely satisfactorily. The nitric acid concentration plant was built in accordance with the recommendations of the Nitrate Supply Committee, to have a capacity of 24,000 pounds of nitric acid in a

twenty-four hour day, calculated as a 100% acid, but being actually delivered as 96%. This plant was designed and erected by the Chemical Construction Company, Charlotte, N. C., but has never been tested.

The present status of United States Nitrate Plant No. 1 is therefore that of many other munition plants throughout the country. It was completed, but had not yet really come into operation when the armistice was signed. It is hoped to keep this plant in partial operation until its measure of success has been determined. The wording of the Nitrate Supply Section of the National Defense Act indicates that at the time the Act was passed, it was contemplated that this plant should be operated for the manufacture of fertilizers. The ultimate disposition of the plant is not yet known.

UNITED STATES NITRATE PLANT NO. 2

U. S. Nitrate Plant No. 1 was built in accordance with the deliberate judgment of the Nitrate Commission, that the direct synthetic process of producing ammonia through combination of nitrogen with hydrogen should be tried in this country, because it did not involve the large amounts of electrical power necessitated by the other processes which had proved themselves successful by actual commercial experience. After this country had been in the war a few months and the loss of ships from submarines became a serious factor, and it was seen that a further source of synthetic nitrate should be supplied, the Nitrate Division unreservedly recommended that the cyanamide process be installed, as involving less electrical power than the arc process, and being the only other process which had been fully developed on a manufacturing scale. The only commercial organization in this country which had expert knowledge of this process and the requisite staff therefore was The American Cyanamide Company. Accordingly, this company was called into conference, and on November 16, 1917, contract was made with them for the erection of a plant to produce 110,000 tons ammonium nitrate per year by the cyanamide process. This plant was to be located at Muscle Shoals, Alabama, and it was proposed to have the plant, to one-half the capacity, ready to begin operations within six months from the date of breaking ground and the remaining half ready twelve months from the same date. The American Cyanamide Company organized the Air Nitrates Corporation as a subsidiary to carry on the actual work and operation of this plant under Gov-

ernment supervision. The exceptionally severe winter of 1917-1918 and the difficulties of getting the large steam turbo-generator units required for the plant, were important factors which delayed construction so that the plant did not furnish its initial product of ammonium nitrate until November 25, 1918. The first unit of the plant which was tested behaved satisfactorily except for small minor defects, and there was every expectation that the plant would have rapidly built up to its full rated capacity by the completion of subsequent units. This plant is now being given a careful test on one unit only, which means about one-sixth its rated capacity. It is expected the test will be completed during the month of January and that the plant will be closed about the first of February, 1919, pending decision as to its future operation.

UNITED STATES NITRATE PLANTS NO. 3 AND NO. 4

In the Spring of 1918 when the losses by enemy submarines were becoming increasingly serious and the stocks of sodium nitrate in the country were reduced to alarmingly low levels, it was decided that additional fixation plants should be erected. The question as to the best process was again referred to the Nitrate Commission who reported unanimously that the cyanamide process was the only one to consider from the standpoint of certainty of operation with reasonable cost. A new contract was accordingly made with the Air Nitrates Corporation, and the American Cyanamide Company, for the erection of U. S. Nitrate Plant No. 3 at Toledo, Ohio, and No. 4 at Ancor, Ohio, near Cincinnati, Ohio. Each of these plants was to have a capacity of 55,000 tons of ammonium nitrate per year. The construction of these plants was well under way when the armistice was declared. Work upon them was at once stopped, and the contracts are now being adjusted and formally cancelled.

CHEMICAL PLANT, SALTVILLE, VA.

The Chemical Plant at Saltville, Virginia, was built at the request of the Ordnance Department and with Ordnance money, but through the agency of the Bureau of Mines with Dr. Charles L. Parsons as its representative. This plant was to produce 10 tons of sodium cyanide per day by the Bucher Process.* The plant was starting

* Journal of Industrial and Engineering Chemistry, March, 1917, Vol. 9, No. 3, pp. 233-253 (1917).

initial operation when the armistice was signed. It was given a test run to get information on operating costs, and was then closed down. It is at present under the jurisdiction of the Nitrate Division of the Ordnance Department, but its future is uncertain.

COMMERCIAL DEVELOPMENTS IN THE UNITED STATES

It is felt necessary to speak with considerable reserve about commercial developments, on account of the confidential relation which the writer has sustained to them in his official capacity. The arc process plant of the American Nitrogen Products Company at La Grande, Washington, referred to earlier in this article, has been in successful operation throughout the war and is the single commercial nitrogen fixation plant known to be in operation in the United States proper, although the American Cyanamide Company at Niagara Falls, Ontario, is still operating with a materially increased capacity. Experimental plants have been in operation testing modifications of all of the five type processes already mentioned. Several of them are adequately backed by capital and it is hoped that successful commercial processes may result. There is a general tendency to go somewhat slowly pending a readjustment of the world's markets.

THE WORLD'S SUPPLY OF FIXED NITROGEN

The world can use almost any form of combined nitrogen, either directly or after conversion into a more desired form, so that the clearest way to obtain a view of the world's nitrogen supply is to reduce the figures for the various nitrogenous materials to a common basis of fixed nitrogen. The nitrogen in manure and other organic refuse, while important for agriculture, cannot be estimated with any accuracy. Figure 1 shows the world's production of fixed inorganic nitrogen expressed in short tons of nitrogen for the years 1909, 1913, 1917. No great accuracy can be claimed for these figures since some of them are mere estimates. It is believed, however, that the general situation is expressed correctly. Much of the data in Figures 1, 2, and 3, is due to Mr. Eysten Berg. The first outstanding impression is that of great growth in each period, but on closer analysis the striking fact is that the percentage increase from 1909 to 1913, when the world was at peace, is nearly as great as during the subsequent period when the world was at war. The increase is very

closely 50% for each four-year-period. The year 1913 shows an increase in production from every source. The year 1917 shows no increase from Chilean nitrate, in spite of the urgent demands of the Allies for greater supply. This was partly due to lack of ships. The greatest increase on the chart for the period 1909-1913 is shown

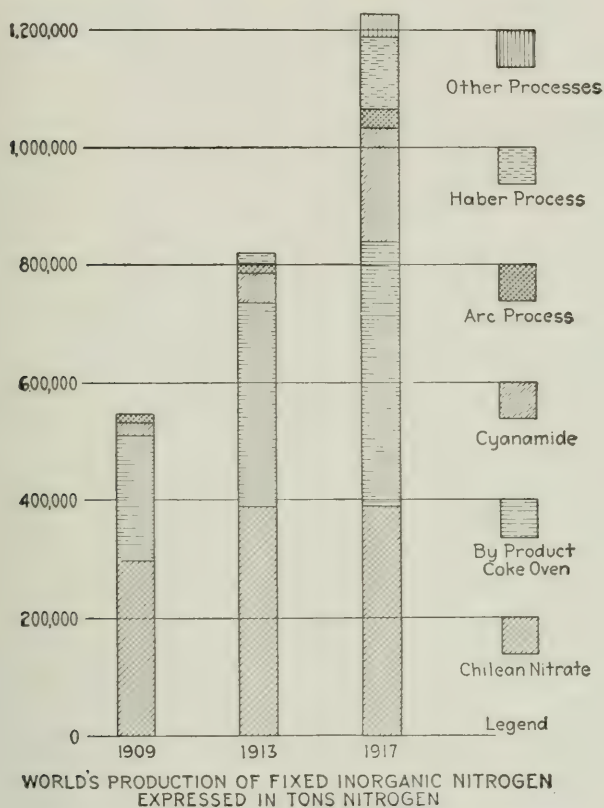
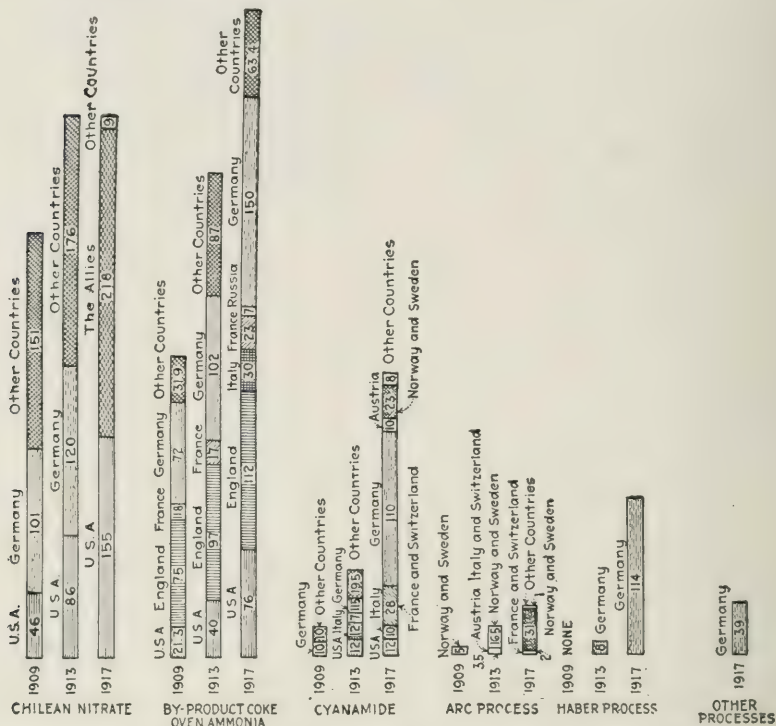


FIG. 1.

by the by-product coke ovens. In 1917 the increase was mainly due to the cyanamide and Haber processes; so that in this year the world's supply came almost equally from the three sources, Chilean nitrate, coke ovens, and synthetic—the cyanamide process being the most important in the latter group, with the Haber second.

DISTRIBUTION OF FIXED NITROGEN BY PROCESSES

In Figure 2, an attempt is made to distribute the world's production of fixed nitrogen by countries and processes. Only approximate accuracy can be claimed for this chart, as was the case with Fig-



WORLD'S PRODUCTION & CONSUMPTION OF FIXED INORGANIC NITROGEN DIVIDED BY COUNTRIES & EXPRESSED IN THOUSANDS OF TONS NITROGEN

FIG. 2.

ure 1, but certain important factors stand out entirely clearly. In 1909 and 1913 Germany received nearly one-third of all Chile's nitrate. After the war broke out, she received none. If the war had continued it is probable that the year 1918 would have seen the Chilean output increased nearly 25% over 1917. This probably represents nearly the maximum output, and it is believed that 500,000 tons of nitrogen as nitrate may be fairly taken as the most that can be expected from Chile.

The figures for ammonia from by-product coke ovens show a steady increase for every country, so that the coke ovens became the largest factor in the world's nitrogen production in 1917. There is every probability that a further increase was registered in 1918. Ovens still under construction, especially in the United States, will afford further material increase in 1919. In the periods studied

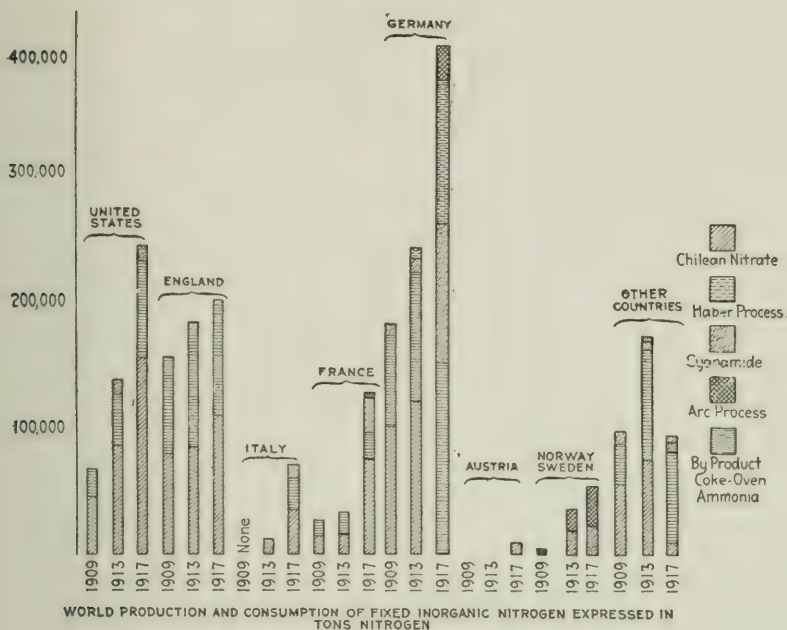


FIG. 3.

Germany shows the largest absolute as well as the largest relative increase in production from coke ovens.

The cyanamide industry more than tripled in each period, and rose in 1917 to a production of more than half of the equivalent of Chilean nitrate. Facilities provided since 1917 make a further increase of 25% possible.

The arc process shows a growth, but in spite of the stimulus of high prices, it has not attained prominence and remains centralized in Norway and Sweden, where water power is cheap.

The phenomenal growth of the Haber process is confined to Germany. The 8000 tons production in 1913 represented success

on a manufacturing scale and gave the German Government assurance that it could go to war, confident that neither foreign navies nor expensive electrical power could keep her armies from an adequate supply of the material most necessary for explosives.

DISTRIBUTION OF FIXED NITROGEN BY COUNTRIES

The distribution of the world's fixed nitrogen among the various countries is approximately shown in Figure 3.

The distribution of Chilean nitrate among the European countries is almost entirely an estimate since much of the nitrate exported from Chile and consigned to Great Britain has been reconsigned on arrival or en route to continental countries.

The most interesting column is that which shows Germany's towering total for 1917, in spite of the entire absence of Chilean nitrate. Here again the figures are an estimate. The relatively small production of Norway and Sweden is also interesting and at first disappointing, in view of the large amount of publicity which has been given the installations in that country.

RELATIVE TECHNICAL DEVELOPMENT OF FIXATION PROCESSES

The two processes first commercially established were the arc process and the cyanamide process. Both have had a commercial development of approximately thirteen years in the hands of skilled chemists, chemical engineers and electrical engineers in countries with high industrial development. There has moreover, been mutual exchange of information between various groups of plants, both national and international, and the industry has become relatively stabilized along lines which represent the most advantageous process which the combined experts of the various affiliated companies have devised. Improvements will still undoubtedly be made, but the processes are relatively highly developed.

Experts in the arc process state that a commercial proposition to be attractive must have continuous electrical power in large units at not more than \$12 per H.P. year. Others state that power must be as low as \$8 per H.P. year. It gives as its sole primary product dilute nitric acid, or an alkaline nitrate or nitrite. There are attractive theoretical possibilities for increasing the efficiency of the arc process, but none have, so far as we are aware, been developed far enough to hold out the hope that the arc process

can ever be successfully operated except where large blocks of cheap electrical power are available. Even the stress of war conditions has failed to bring about the establishment of really large plants anywhere but in Norway and Sweden, and the total output by this process only amounts to about 3% of the world's total.

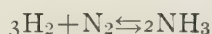
The cyanamide process has been studied since 1898 and has grown until in 1917 it furnished approximately one-sixth of the world's total fixed nitrogen. It requires large amounts of electrical power, but only one-fourth as much as the arc process. It also requires as raw materials, large amounts of pure limestone and coke. It yields calcium carbide as an intermediate and cyanamide as its primary product, with ammonia, nitric acid or ammonium nitrate as subsequent products obtained by relatively efficient processes. It stands as an example of a highly developed chemical industry dependent for commercial success upon relatively cheap electrical power in large units. The war has seen one variant of this process receive an extensive test in this country on a semi-industrial scale, with such favorable result that a commercial plant is now being erected.

While many metals yield nitride when heated in nitrogen, the manufacture of aluminium nitride has received the most attention because of the possible importance of the alumina obtained as a by-product, for the aluminium industry. It requires large amounts of electrical power and a rather specific raw material—bauxite. The commercial developments of the past have not been successful, and although more is hoped from the two large semi-commercial installations now being tested in this country, it must still be regarded as a rather unproven process.

The cyanide process does not require electrical power and uses as its raw materials sodium carbonate, coke, iron and pure nitrogen. Of the raw materials the iron is always recoverable and if the cyanide is converted into ammonia under proper conditions, the sodium carbonate is also recoverable, leaving as the only raw materials actually expended nitrogen and coke in the cyanizing reaction, and steam in the ammonia reaction, together with the coal required to furnish the heat. The initial product is cyanide which may be purified and marketed as such or converted into ammonia with a possibility of sodium formate as a by-product. The development has been largely in the United States since the war broke out. It has been studied carefully by the United States Government and by several private corporations in plants almost large enough to be called commercial plants.

The only really large scale plant is the United States Chemical plant at Saltville, Virginia, previously referred to. The commercial possibilities of this process have not yet been established. The present developments have tended towards an externally heated steel or nichrome retort as the most suitable container for the cyanizing reaction which requires a temperature of 1000° to 1100° C. The retort is necessarily small and the reaction is rather slow. The process attracted the Government during the war because it was certain nitrogen could be fixed without the use of large amounts of electrical energy, which were then almost unobtainable. At present the process involves high capital, labor and repair costs. The process must not, however, be condemned in its present immature form.

The direct synthesis of Ammonia from nitrogen and hydrogen was first developed both from the theoretical and practical side in Germany, and the name most frequently associated with it is that of Haber. The combination of nitrogen and hydrogen according to the reaction.



is favored by high pressure and relatively low temperature. Some of the equilibrium values are given in the following table:

PER CENT NH_3 IN EQUILIBRIUM AT VARIOUS PRESSURES (IN ATMOSPHERES)

$^{\circ}$ C.	1	30	100	200
300	2.18	31.8	52.1	62.8
500	.129	3.62	10.4	17.6
700	.0223	0.66	2.14	4.11

The rate of reaction between the gases is altogether too slow to be commercial unless accelerated by a catalyst. Our knowledge of catalysis is still very vague and catalysts are discovered only by tedious experiments, largely empiric in their nature. Furthermore, they are extraordinarily susceptible to poisons.

While therefore the reaction between nitrogen and hydrogen is extremely simple to write, it is extremely difficult to carry out economically. The successful solution of the problem involves many problems but they may be divided into the following groups:

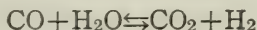
1. Preparation of pure nitrogen.
2. Preparation of pure hydrogen.
3. Preparation of catalyst.
4. Construction of plant.

PREPARATION OF PURE NITROGEN

It is unfortunate that the term fixation of nitrogen fixes attention so strongly on nitrogen that the lay mind gains the impression that one of the chief difficulties to be overcome is the preparation of the nitrogen. The arc process starts with air but all the other processes require or at least work distinctly better if supplied with nitrogen substantially dry and free from oxygen, carbon dioxide and carbon monoxide. Argon, helium and other rare gases of the atmosphere interfere only as they dilute the nitrogen slightly. The supply of pure nitrogen is important but fortunately the liquid air process furnishes it so cheaply and reliably that the problem may be considered as solved. A nitrogen column as delivered to the United States Nitrate Plants has an hourly capacity of 20,000 cubic feet of dry nitrogen, with less than 0.1% oxygen for an expenditure of 180 H.P. hours. Power is by far the most expensive item for air is free, only a small amount of caustic is needed for purification of the entering air and the labor charge is small. The operation is so reliable and the cost so small that efforts to recover waste nitrogen from industrial sources are hardly worth while where a really large installation is being considered.

PREPARATION OF PURE HYDROGEN

Pure hydrogen is needed only for the direct synthetic ammonia process. It forms 17.6% of the theoretical gas mixture by weight, but 75% by volume. Hydrogen is formed as a by-product in the electrolytic manufacture of chlorine, but the expense of collecting it and purifying it is considerable. Hydrogen and oxygen are obtained by electrolysis, of caustic solutions, but it is difficult to find a location where both gases can be used to advantage. It is also made by the action of steam on red hot iron and by the water gas reaction wherein steam reacting with coke produces approximately equal volumes of carbon monoxide and hydrogen. By further reaction with steam in presence of catalyst as shown by the following equation:



most of the carbon monoxide may be removed with the formation of an equal volume of hydrogen but a long and elaborate purification process must be followed to bring the gas to a pure and dry state. The refinement of purity necessary will vary with the different catalysts, but the impurities must certainly be measured only in hundredths of a per cent, if not in thousandths. Further research work on the purification of hydrogen is desirable.

FUTURE OF NITROGEN FIXATION PROCESSES

The future of the nitrogen fixation industry can only be forecasted in the most general manner. It depends upon two factors—the demand for fixed nitrogen and its price. These two factors are in part independent and in part linked together, for a lowered price is certain to cause a greater demand. The principal demand of the last few years has been for munitions, and the demand was an insistent one which had to be met regardless of price. The great normal demand for fertilizers has been restricted to a minimum. The largest demand for fixed nitrogen in the future will probably be for fertilizers and the use of fertilizers will be very largely a matter of price. The diagram of Figure 1 shows an increase of roughly 50% in output for fixed nitrogen for each four-year period. It is not probable that 1921 will show such a proportionate increase although if all the resources of Chile and all of the facilities in the way of coke ovens now under construction, and fixation plants should be utilized, the year 1920 might well see a possible production of 25% more than 1917. What will be the cost of production? The cheapest source of fixed inorganic nitrogen will undoubtedly be the ammonia from by-product coke ovens because it is a by-product and the cost of collecting and putting it into marketable form is small. The coke ovens of the world can now produce more fixed nitrogen than the world used from all sources ten years ago. It will be a powerful factor tending towards low prices. It is probable that Chilean nitrate could, if necessary, be sold at lower prices than in former years. The fixation processes will therefore have to be prepared to meet possible low prices if they are to be ranked as anything more than emergency reliances.

The cost of nitrogen in the staple raw materials sodium nitrate and ammonium sulphate varied from \$12 to \$18 per hundred pounds in the years 1900-1915. It is manifest that a process which is to

produce a large proportion of the world's fixed nitrogen must be able to compete with these staple materials. Smaller factories may produce specialized products such as sodium nitrite and anhydrous ammonia for which there is a demand, large in itself, but small in proportion to the world's total demand.

The necessity and the possibility of independence of Chilean nitrate as a material for munitions has been proved in the past four years. The question as to whether the fixation processes can compete with Chilean nitrate and coke oven ammonia in times of peace, and for the cheapest commercial nitrogenous product-fertilizer can not yet be answered.

The cyanamide and arc processes both labor under the handicap of the requirement of large amounts of electrical power. The nitride process has a somewhat similar handicap but possesses a possible advantage in the recovery of alumina as a by-product. The cyanide process labors at present under the disadvantage of small manufacturing units but has the advantage of low power requirements and the possible recovery of formates as by-products. The direct synthetic ammonia process presents great engineering and chemical difficulties, but has the great possibilities of future development. As will be seen from the table earlier in this paper, if an inventor could find a catalyst active at 300°C ., he would have the theoretical possibility of increasing the conversion by one passage through the apparatus at 100 atmospheres pressure to fivefold the conversion at 500°C . Or with such a catalyst, he could work at 30 atmospheres pressure and 300° temperature, eliminating thereby many of the serious engineering difficulties and still obtaining a conversion far better than anything now commercially known to us. There is no theoretical reason why such a catalyst might not be made and its discovery would offer the possibility of cheaper fixed nitrogen than anything heretofore known.

DISCUSSION

The PRESIDENT: Is there any discussion of this very interesting paper? We are very much indebted to Col. White for the presentation of it.

Dr. REDMAN: Col. White has very studiously avoided telling us what the catalyst was. If it is the same as they have in Germany or if it is poorer than they have in Germany I don't see what the

danger can be in telling us. If he can tell us I would like to know particularly what effect carbon monoxide has.

Col. WHITE: Carbon monoxide is supposed to be detrimental. I am not at liberty to tell you what the catalyst is.

Mr. BRECKENRIDGE: I would like to ask Col. White about what yield can be obtained in the synthetic process in going from ammonia NH_3 to nitric acid. I would like to ask something about the yield with pure ammonia and what is the influence of the poisons that may be introduced?

Col. WHITE: The gauze efficiency may run as high as 95%; the overall efficiency including tower efficiency may run 85-90%. The poisons in the gas are quite largely sulphur and phosphorus compounds. If the gas is pure enough it can be used with a catalyst whose heat is self-sustaining without electrical energy. If it carries phosphine it probably will require electrical heating of the gauze to enable it to recover from the effects of poison.

Dr. ANDREWS: I would like to ask if the carbon monoxide in the hydrogen, after it has been reduced, say to 3 or 4 per cent, may be removed on a large scale by reaction with heated caustic soda.

Col. WHITE: That reaction has been patented, as you probably know, and is contained in one of the group of Haber patents. It works pretty well but not completely enough to be adequate without a supplementary process to remove the last traces of carbon monoxide.

Dr. JONES: I would like to ask what part of Germany those plants are located in, particularly whether they are in the occupied zone. (Laughter.)

Col. WHITE: I don't know where the new plants are. Some of the original plants are in the occupied zone.

Mr. ANDREWS: I think we would be very much interested to find out just how this information about Germany was obtained. (Laughter.)

Col. WHITE: I don't know the exact sources. It comes filtering through. Perhaps it comes through Switzerland and Norway, but that is guessing in the dark. Such information can not pretend to be accurate. Not many of those figures in the charts are really accurate. They are only useful for general impressions, because people who are supposed to know, differ rather widely in their estimates. The general impression is, however, fairly accurate.

Mr. BRECKENRIDGE: I would like to know the concentration of nitric acid after the oxidation of NH_3 with oxygen.

Col. WHITE: From the arc process about 35% nitric acid is obtained and from the oxidation of ammonia about 50% acid.

Mr. BRECKENRIDGE: Either using air or oxygen?

Col. WHITE: We have no actual large scale tests on the oxidation of ammonia using oxygen as the oxidizing agent. It will naturally result in a higher concentration of oxides but we have not done anything except on a laboratory scale. It is necessary to be careful there or an explosive mixture results.

Mr. BRECKENRIDGE: Have you found out any use for the extra amount of heat, formed in the ordinary process of using air?

Col. WHITE: It can be utilized in some cases to heat water or generate steam in the condensers.

SYNTHETIC PHARMACEUTICALS AND THE PATENT LAW

By JULIUS STIEGLITZ

Read at the Chicago Meeting, January 19, 1919

Mr. Chairman and Gentlemen:

Only about a week ago I was commanded by our local chief, Dr. Redman, to be prepared to represent the Chicago Section of the American Chemical Society on your program this evening and I was able to accept the honor only with the explicit understanding that I would speak informally and as briefly as my respect for this distinguished audience would permit. Only yesterday did I learn the complete title of my paper—"Synthetic Pharmaceuticals and the Patent Law." I shall address myself primarily to the problem of the synthetic drug and say as little as possible about the patent laws, and that little as a friend of the people and not as an expert.

Now that the war is over and we are free to consider the great, humane problems of chemistry, the problem of the synthetic remedy, in which I would include the closely related work of the isolation of pure active principles from natural sources, must be considered one of the supreme problems before the chemists to-day. Its goal is to discover or prepare pure specifics to destroy invading germs and thus cure disease, to discover other specifics to cure or at least alleviate disease by helping the body over the difficulties of a shortage of production, or of overproduction, of the secretions whose normal activities keep us in good health. Any advance made is made for all time, for the benefit of all. A promise of success in combatting numberless ills of man by chemical interference is contained in the results thus far obtained. Quinine is a specific for malaria; within the last ten years Ehrlich prepared a sovereign remedy for that dread disease syphilis, a remedy of which I shall have more to say presently. Then we have a specific for uric acid poisoning, the bane of the gouty—phenyl cinchoninic acid as our learned U. S. Pharmacopœia calls it, or atophan, as the physician prescribes it. Such results—and they are only instances—certainly

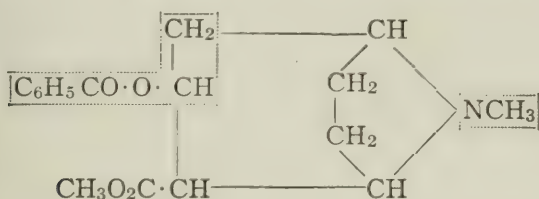
promise us continued success in the tremendous field of combatting disease by the efforts of the chemist in the aid of mother Nature.

To-night I shall limit myself to the question as to which lines of effort give the greatest promise of achieving further results in the shortest time. There are two such paths that I want to discuss—each, only in outline. The one way is to take natural drugs and examine them most exhaustively, determine, in short, the structure of the molecule of the pure active principle—and then with the key to Nature's secret thus in hand, to invent something even better. It is a fallacy to which you, of course, would not be inclined, but which the common man is prone to yield to—it is a fallacy to believe that what is natural is better than what is artificial. Is not the whole history of civilization, sadly as it lacks complete emancipation from the more savage instincts of Nature, evidence that the mind of man, directed on ideals, is more powerful in alleviating ill than Nature ever was or ever is, in the blindness of her work? The old fallacy, to mention a chemical case in point, that natural salicylic acid is better than the synthetic product is a simple instance of the deep-rooted prejudice of man toward the chemical laboratory. We can, in fact, take natural remedies, examine them exhaustively, and then improve on them—and presently I will discuss instances of this kind.

The second path of development is to strike out boldly as chemists independently of natural remedies and make products artificially and in cooperation with pharmacologists try their pharmacological effects, improve them, discover their flaws, improve them still further, until finally, step by step, we succeed in obtaining what we want. Arsphenamine—the official American name for “606”—is the greatest instance of this kind in history, and we shall presently dilate somewhat on it.

Now, let us consider in detail some illustrations of these two lines of effort. Perhaps the most brilliant instance of the success following the exhaustive study of a natural product is the case of cocaine. Perhaps some twenty-five years ago cocaine was found to have the invaluable property of producing local anesthesia. That is, injected under the skin, it deadens the sensitiveness to pain locally, for instance to the pain that normally would be produced by the action of the knife of the surgeon. That important observation led to its free use in medicine. But cocaine was found to have two faults. First, it is extremely toxic and occasionally a fatality

occurred in comparatively minor operations, say in a dentist's chair. That, of course, is a very serious drawback. In the second place, cocaine has always been rare and expensive. Well, organic chemists studied cocaine exhaustively and after extremely hard and painstaking work by some of the most brilliant minds the very complex structure was finally determined correctly. It took three series of efforts by leading chemists, a fact which you can appreciate when I put the structure of the molecule on the blackboard for you—which I will do, because it will enable me to point out exactly how we use Nature's own lesson to improve on her work.



You notice, to use a homely simile, that the molecule of cocaine appears as a kind of "three-ringed circus"—which is always an expensive undertaking and with three-fold chances for most dangerous and unforeseen consequences. Seriously, however, with this structure of cocaine before them, chemists were able to ask the question, which of these many atomic groups give cocaine its valuable properties. That is the ultimate question and that is the purpose back of all of this extremely difficult work. Which group or groups of atoms make cocaine a local anesthetic? We have used the same method of analysis with wonderful success in developing dyes—here is the key to a similar and far more important campaign into the realm of curative medicine. Three of the groups of atoms in cocaine were found to include the essential ones: the tertiary alkylated amine group, the ester group and the aromatic nucleus of the acid of the ester. I have indicated the essential groups by faint dotted lines surrounding them. Very much simpler artificial compounds have been prepared which have the essential property of producing local anesthesia with a far lower degree of toxicity. Quite a number of such substitutes for cocaine are now known, but perhaps the best of these is procaine—the official American name for the drug introduced as novocaine. I am going to put down its structure in order that you may see the resemblance of its

structure to that of cocaine in the essential points—which are again indicated by dotted lines:



How evident is it that we have eliminated everything that is not essential, that could be harmful.

Here too is an American invention apothesine, one of those few beginnings on the trail which many of us hope to see develop into a great highway of progress:



Note well that in the three-ringed molecule of cocaine we have with the active, anesthesia producing groups, the same extraordinarily toxic hexahydropyridin ring as in coniine, the poison in hemlock, notorious for its being the poison taken by Socrates when he was condemned to death for being wiser than his fellowmen. We also have the reduced pyrrol ring, as it exists in nicotine, another deadly poison if taken in more than minute quantities. These three-ringed effects—the rings are extraordinarily stable and hard to break and destroy—a characteristic of rings in general—have, you will note, been successfully avoided in the synthetic anesthetics which we are discussing. We have reduced probably to the smallest possible molecule the exact effects we are seeking for in this type of compound, and that obviously is of great advantage to the system in the elimination and destruction of the drug after it has served its purpose.

A second instance, which I will mention without troubling you with molecular structures, where the chemist has improved on nature in a very simple fashion, is the case of hydrastine, the active principle of *hydrastis canadensis*. This was used internally to stop internal hemorrhage. After the isolation of the pure active principle—its structure was eventually determined by Freund—it was found that oxidation cleaves the molecule practically in twain and produce a new compound, called hydrastinine or the "white alkaloid," which acts very much faster than the original hydrastin—as if the latter were active perhaps only after the body itself had oxidized it to hydrastinine—although that is not the case. It is evident

that when we are bleeding internally, we want to have the hemorrhage stopped just as speedily as possible—no drug could act *too* fast—and so, this improvement on the natural product is one of essential importance. Here again, with the accentuation of the main action desired by taking only the essential part of the molecule, untoward secondary effects also were eliminated.

One other instance, of a different type, of what the chemist can do in the laboratory comes to my mind—the isolation of the pure active principle of the suprarenal gland, suprarenin, by Dr. Abel of Johns Hopkins University, and its preparation on a commercial scale by Dr. Takamine's method. It is known commercially also as adrenalin. It has the important property of contracting the blood capillaries and is used with the newer anesthetics for this effect. The isolation of the active principle makes it possible to inject hypodermically the pure compound and achieve results which the natural secretions, with their load of accompanying material as Nature prepares her principles, made quite impossible. What the advance means I have recently had brought home to me: for twenty-five years occasionally I have had to watch the distressed efforts of a patient suffering from acute asthma, with the poor resource of offering only palliatives, but no decided help. But now, a small hypodermic injection of adrenalin brings blessed relief—within half an hour the patient is sleeping easily. What a tremendous advance after twenty-five years of suffering—and hundreds of years for thousands of other sufferers since the dawn of medicine. The regret comes that we have not had this simple remedy sooner—and that means, of course, that chemists must now concentrate as never before in this field of wonderful possibilities in curing and alleviating disease, to achieve results as speedily as possible.

If we turn now to the second path which we may follow towards this goal, the most brilliant and instructive instance of success in the effort of the chemist to fashion his own ingenious curative molecules without the aid of any clues from Nature, is Ehrlich's monumental work in inventing "606" or salvarsan—now known as arsphenamine. The very name "606" indicates the nature of the path followed—that is, Ehrlich developed his molecule step by step, modifying it here a little, there a little, until he was satisfied with the result after 606 steps had been taken. It is a drug rich in arsenic, which injected into the blood will kill the germ of syphilis, without injury to the host—if properly prepared and properly used! It is

extraordinarily important as the war has taught us: if used within ten days of infection, it is said to abort the disease—a tremendously important result, if we are to stamp out this dread disease, as we hope to do. Used in later stages, it is slower and must be used with patience—but it is still supremely valuable, as compared with other agents. There are official estimates that there are no less than ten million people afflicted with this loathsome disease in the United States, a disease weighing most heavily on the innocent generations to come. As you probably know, the Public Health Service is instituting a national campaign to suppress the disease—largely through local, social measures, but also by proper medical treatment. In Massachussets the State is already manufacturing arsphenamine and using it free of charge on thousands of patients. The state of New York is studying energetically the processes for preparing this important drug for State purposes. I am emphasizing this for a twofold purpose—first to impress you with the tremendous importance of a drug developed by the chemist in his laboratory, without using any model found in nature, and second, because in discussing patents, I shall want to use arsphenamine as an object lesson. Let me add that in my opinion arsphenamine is not the last word in the development of a remedy even for syphilis—it is the best we have now and *it has pointed the way*. It has its disadvantages. It is a terrific poison, it is difficult to prepare and yet must be quite pure, otherwise it will cause serious reactions and sometimes even death. Can we not find something equally as effective and not so dangerous—as we did in the case of local anesthesia? What pressing problems in related fields urge themselves upon us—a specific to kill the pneumococcus germ would have saved hundreds of thousands of lives in our present epidemics, lives sacrificed to disease innocently acquired! This country must develop these lines of chemical effort as intensively as it developed its war agencies—and the effort must be cooperative to succeed, some supplying the necessary research institutions and funds for their successful maintenance, others giving skilled pharmacological assistance—the chemist being the builder, the architect in the molecular world of construction!

I want to turn now briefly to the second part of the topic I was asked to discuss, namely the relation of synthetic chemistry to patent laws. I speak as a layman and as a friend of the people, *amicus curiæ*, I believe is the Latin of it, not as a manufacturer or one directly interested in patents. From that point of view, I would

like to express the opinion that as far as our patent laws affect anything dealing with public health, they seem to me to be the worst laws that we find in any civilized country! In France, as I understand it, no remedy, no article, concerning the public health may be patented. In England, every patented article must be manufactured in that country within a few years in sufficient quantity to supply at least a definite part of the needs of the people. In Japan the *product* may not be patented, though the process may be, as I understand it. Arsphenamine or salvarsan, for instance, as a product is not patented in Japan, with the result that the Japanese have been able to develop their own processes, making an excellent article for their own use and for export. In the United States we have the product patent, the process patent and no law demanding that a patented product must be manufactured in the United States. We have all the defects and none of the advantages of an up-to-date patent law in matters of moment to public health. You are all familiar with the result: when importations from Germany were cut off and we were put to it to meet the insistent demand for important remedies and for a time the situation was an extremely serious one—indeed, for some remedies, such as luminal, an excellent hypnotic in epilepsy, the situation is still a most serious one to this day—and in my judgment our patent laws have been the root of the difficulties. There were far too many cases of what we call “Bulgarian operations” in our hospitals, operations without any anesthetic whatsoever, throwing the people back to the tortures of former generations because of the lack of supplies. If we had had at least the British provision in the patent law, that a patented product must be manufactured in this country to provide at least a part of the normal need, then we would have had constant sources of supply of at least a part of our needs, sources of supply, indeed, which with a minimum of trouble and delay could have been expanded to meet the whole need of the country—as was the case in the more fortunate British Isles. Luminal, as just now stated, is an invaluable hypnotic in the treatment of epilepsy and as chairman of the Committee on Synthetic Drugs of the National Research Council I have had letters from physicians and parents from all parts of the country, begging for luminal. We even went so far as to develop within two or three months an improved method of preparation at the University—the patented process gives distressingly poor yields—and published the results for the free use of any manufacturer to help this need.

But we found that the title to the American patents rested in American hands, in a company which only after the war was over was found to be controlled by the enemy and whose property was sold in December, 1918 by the Custodian for Alien Property; that American owned patent was a *product* patent and it was impossible for the Federal Trade Commission to grant a license to manufacture it. We did interest two houses to secure from the controlling agents the right to manufacture luminal—but in the absence of real, open competition progress has been so slow, that it is even now not on the market. As it is a product patent, our improved process can serve only to benefit the owners of the patent—the American public is not benefited in the least.* If Germany had happened to sell the American arsphenamine patents to an American company, which might have refused to manufacture it or have undertaken to make it only in the half-hearted, intolerably dallying way in which the problem of luminal was taken up under such circumstances, this country would have paid in the lives and undermined health of its army, navy and civic population for the vital defects in our patent law as it concerns matters of public health. Fortunately, the arsphenamine patents were enemy owned and the Federal Trade Commission had power to issue licenses for its manufacture. There was in fact a great deal of competition for such licenses—there could be no competition for the manufacture of luminal, thanks to our patent laws, and we have never obtained any. The result in regard to arsphenamine is that it is made in this country as good as, or even better, than the original imported article; we are making in one month as much as was imported in a whole year before 1914; and it is being supplied to the army, navy and public at \$1.00 to \$1.50 per dose—under government regulations—as compared with a price of some \$4.50 per dose before 1914 for the imported article. This is the result with chemicals and labor at war prices, and in normal times the price should be considerably lower.† For a time, before the Ameri-

* Since this was written, the Luminal patent knot has been cut by the energetic action of Mr. Francis P. Garvan, Custodian for Alien Property. When the situation discussed in this paper in regard to Luminal was brought to his attention, Mr. Garvan at once proceeded to make arrangements to have the makers of Luminal market their product through the present owners of the patents and the drug has thus been restored to the market.—J. S., May 12, 1919.

† This price has since been reduced to 60 cents per dose to States, Municipalities and Hospitals.—J. S., May 12, 1919.

can product was available, fancy prices of ten and twenty dollars were paid per dose by frenzied victims of the disease. I am emphasizing this fact for this reason: Most likely the treaty of peace will put patents into the *statu quo ante*. That will mean that under our patent laws, controlling the product as well as the process, the exclusive right to manufacture arsphenamine is liable to go back to Germany; and our own manufacturing plants, which have improved the processes and the product and are supplying it at one-third of the pre-war price, will have to close up or pay ruinous tribute to Germany. Germany would have indeed the very health of our people at its mercy—remember there are probably more than ten million people in this country who ought to be treated to stamp out this dread disease. What American can contemplate with equanimity delivering our people to the tender mercies of our present enemy in this matter of the health of the Nation—and yet, that is what will inevitably follow under our present patent laws unless the Treaty of Peace or Congress by special action should make special provision to prevent the otherwise irremediable consequences of our patent laws. We are making a special and urgent appeal to Congress and, indeed, to our peace delegates, the problem is so vital a one for the country.† We cannot afford to delay the campaign to suppress syphilis even for one year—the public is ready for the campaign and delay would be at the price of an untold loss in health, life and efficiency of our people. Now, France, Japan, and probably England, are not facing this difficulty—because they have patent laws which protect their people in matters of public health.

In conclusion, I would recommend therefore that our patent laws be revised at least to the extent that product patents be not granted on inventions of concern for the public health. I am speaking here for the people and as a layman against the opinions of good friends of mine, who are experts, such as Dr. Baekeland, Dr. Hesse and others. After all, I rather feel that they may be speaking for the people who take out and own patents. There is rarely an instance, in fact, where an inventor does not owe quite as much to what has been the common property of the world as to his own ingenuity; even Ehrlich's campaign against the syphilis germ was founded in part on the observations of Thomas and Breinl in the study of tropical diseases in the Research Institute of Liverpool,

† This has probably been taken care of since this statement was made.—J. S., May 12, 1919.

in regard to the effect of atoxyl, the arsenical forerunner of arspheamine. A share of the public in such inventions as against exclusive control by means of product patents seems to me therefore not only desirable from the point of view of the best interests of the public but also ethically right.

Let me give another instance: Baeyer's fundamental work on the structure of indigo on which all artificial processes for making indigo are based, gave him fortunately only process patents for his own processes. If he had been allowed a product patent—which was not possible, as indigo is a natural product—the really successful processes for manufacturing indigo on a commercial scale at low cost would not have been developed or would have had no rights—as is the case with the improvements in the processes to manufacture arspheamine.

Personally I believe therefore that in the case of remedies our patent laws should be amended to exclude product patents. I would also adopt the British regulations insisting on domestic manufacture of patented articles, with the penalty of forfeiture of patent rights.

Finally, my great hope is that this wonderful work of developing synthetic remedies, of improving on natural remedies, of isolating pure principles for medical use, will be taken up most intensively by research institutes—the Rockefeller Institute is already working in this direction—and by universities, and that the discoverer of new important products in these institutions perhaps with a very small return, will be satisfied to give their discoveries to the public as a scientific gift under such restrictions only as will insure their exploitation for the public. We have the magnificent instance of the gift of Dr. Cottrell of the University of California, of his smoke devices for the benefit of research. We cannot expect commercial houses to forego large returns on their investments. Let our government laboratories, our research institutes and the universities produce these blessings of chemical effort and give them free to the world as they do give freely their acquired knowledge, their scientific discoveries. That would be my solution of the patent difficulty!

DISCUSSION

The PRESIDENT: I am sure we are all very much indebted to Dr. Stieglitz for his talk to us to-night, for his illuminating explanation of the ideas that he has presented for the production of synthetic pharmaceuticals and also his ideas with regard to patent legislation. It would be very desirable if we could have some discussion on these subjects. I don't know how many would feel themselves competent to discuss the first part of his subject but in the second part all of us more or less have a vital interest and we certainly would have some ideas to express.

Mr. BRECKENRIDGE: I was very much interested in the patent portion of this talk but I was also very much interested in the first portion of the talk. Take the case of aspirin, I was just wondering if Professor Stieglitz would venture a suggestion or a thought as to what would be the result if we should substitute a butyric acid radicle in the aspirin, whether we could expect a better or a worse effect or just what we should expect in such a case. I sat in Professor Stieglitz' class room and I have asked questions before.

Prof. STIEGLITZ: I am not sure what the effect would be. Of course, the butyric acid radicle would make it the more difficult to dissolve the products and for that reason I imagine if for no other, acetosalicylic acid would be preferable.

QUESTION: How about formic acid?

Prof. STIEGLITZ: Formic acid is not very good for us (laughter). I would not know what the advantages would be. Acetosalicylic acid was made before aspirin and aspirin sells through its name. Another difficulty of our patent laws which I should have pointed out and which is recalled to my mind by this is that the brand name lives after the expiration of the life of the patent and although the patent has expired, other persons or firms cannot use the brand name. That is one of the objectionable features which we ought to improve. One way to do it would be to use simpler official names. The worst way to do it is the way the United States Pharmacopœia has gone about it, namely, to call acetyl-salicylic acid acetyl-salicylic acid. No physician will remember such a long name and will generally put down aspirin. The doctor has too much to think about. If we can give these things short names the doctor will use them.

The PRESIDENT: It is unfortunate that we have such scientific names for the benefit of physicians, but I suppose it must be so.

Mr. HIRSCH: We cannot give thanks enough to Professor Stieglitz for what he has told and elucidated to us for the study of new remedies in this way is certainly very important in the present day but I would like to call attention to one fact that the healing remedies of nature are not alone in the new organic compounds but they are also in the mineral compounds if properly used and classified as they have not been in medicine. You take the prescriptions of 50 or 60 or 70 years ago and they were the short form prescriptions, everything in them, if possible, so that one of the things might work although it might work against the benefit of others. Chemists have eliminated a great deal of that and to-day the most of the doctors who practice successfully use the new remedies made by chemists but not by physicians. Now I have always led a private life as a chemist and studied a great deal and accomplished a good deal, which I have not published, because I never had time to rush into print. Of course everybody knows that the manufacture of glucose from corn is my patent, 1865, and it is to-day in the hands of a company, a trust, with eighty million dollars stock. I have not received even one million. All I have left of it is a medal which, in 1865, the American Institute gave me for that.

Now, speaking of medicine, if Professor Stieglitz, through his physicians, will furnish me one hundred patients with rheumatism whom the physicians are treating, I will guarantee to cure 80 per cent of them inside of one week and the most of them inside of three days. I have done it and I have living witnesses even in this town, to prove it. The same way about asthma. I have letters from people who have suffered for years with asthma, and the remedy, which was not organic, cured them within one week, and I am ready and prepared to do the same thing to-day. A few years ago we had quite an epidemic here of poisoning by bichloride of mercury. It was my remedy which I gave to several physicians who cured every one of twenty-five cases. I have the letters from the physicians who received my advice and it succeeded. Only one of them tried to rob me of the glory. I never made one cent out of it and never intended to.

The PRESIDENT: Mr. Hirsch, may I interrupt you? We would like a little discussion of Dr. Stieglitz' paper. I think if you would let some of the members present now speak it would be—

Mr. HIRSCH: I beg your pardon. I have started out with praising Dr. Stieglitz. Dr. Stieglitz needs no praising, but I wanted to suggest a different road to the same result and its benefits to humanity.

The PRESIDENT: Is there some further discussion of Dr. Stieglitz' paper? I am afraid the patent subject would be one that we are all afraid to say very much about because we are afraid we will start a discussion that will keep us here until the middle of the night. I am simply going to say this, with regard to the patent subject that while I might agree with Dr. Stieglitz in principle I am very much inclined to think that what can be done is simply to construct a number of artificial systems with regard to your patent laws and then study those artificial systems to see which is the least objectionable and adopt that. I don't see for my own part how you can get a patent system that won't have a great many objections, and the only thing you can do is to pick out the least objectionable system. A lot of people would think we had decided against them. We would have a very large number of men to average up various opinions and pick out the least objectionable system. We can all agree with Dr. Stieglitz that in so far as public health is concerned, some method ought to be devised whereby remedies necessary for the public health should always be available. How that is to be done, as far as that particular thing is to be done, I do not know. Perhaps with regard to these particular things that Dr. Stieglitz has spoken to us about his method might work, but it might not work with regard to a great many other commercial matters in which public health is not involved. However, I do not want to take up the time in discussion.

Mr. KEMP (Director Burdett's Research Laboratory, 3223 Sheffield Avenue, Chicago): I am not a member of this society. I came here rather as an intruder this evening, but I came here out of interest in what Col. White had to say and stayed because of my knowledge of the next speaker and his work. The patent subject I do not think, though, should be completely neglected in this after-discussion. I feel as you feel when public health is at stake it is very vital perhaps to make some marked changes in the system, but Dr. Baekeland, who has been exceptionally kind to me in giving me advice as a research engineer, which is my work, is a practical example of a man who has climbed his own ladder, you might say, on the protection that the country has given him, and but for that protection

he never would have had the resources to operate his private laboratory and produce empirical results in various chemical lines that he has produced. That is a rather serious point with many people working along original lines that use that as their only source of income and who must rely upon the protection that the Government affords them for the continuance of their researches. If this is to be given attention it should be, as you say, considered with extreme care. Each item or each class of items that was under discussion should be looked at from somewhat such a standpoint. Where public health is concerned nothing should stand in the way of broad use, but where the results of private endeavor, even though they may be built on the results of past generations, are finally patented, and those results are the cause of vast expenditures of money they certainly ought to receive the best possible protection.

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Technical Foreman in charge of Caustic Finishing, Caustic Evaporation and Salt Departments of the Penna. Salt Mfg. Co.
- TUNISON, BURNELL R., 27 William Street, New York City.
Development Chem. Eng. and Technical Adviser to the Sales Department of U. S. Industrial Alcohol Co. and U. S. Industrial Chemical Co.
- TYLER, STEPHEN L., 50 East 41st St., New York, N. Y.
Technical Engineer, Thermal Syndicate, 50 East 41st St., New York, N. Y.
- WALKER, GEORGE E., 7 Beecher Terrace, Newton Centre, Mass.
Chemical Engineer, Viscal Company, East Cambridge, Mass.
- WHEELER, THORNE L., 280 Madison Avenue, New York.
Wheeler & Woodruff, Chemical Engineers.
- WILSON, ERNEST D., Worcester, Mass.
Chief Engr. Lab., The Graton & Knight Mfg. Co., Worcester, Mass.
Intravenor Prod. Co., 3757 Wazee Street, Denver, Colo.
- WOOD, BURTON G., 1800 S. 2d St., St. Louis, Mo.
Mfg. Chemist, Monsanto Chemical Works.
- ZIMMERLI, WM. F., 185 Park Avenue, Rochester, N. Y.
Chief Chemist, Pfaudler Co., Rochester, N. Y.

MEMBERSHIP BY STATES AND CITIES

ALABAMA

Sheffield

CHAMBLISS, H.

Anniston

KLUGH, B. G.

Selma

THOMPSON, P. H.

ARKANSAS

Little Rock

LUFT, O. W.

CALIFORNIA

Beverly Hills

SHATTUCK, A. F.

Berkeley

O'NEILL, EDMOND

Burlingame

DOLE, N. E.

Colton

HANNA, W. C.

Crockett

DUPERU, A. M.

Glendale

DEAN, J. G.

Heroult

CLARK, W. W.

Los Angeles

BARUCH, EDGAR

SCHMIDT, W. A.

Oknard

ZITKOWSKI, H. E.

San Francisco

GOULD, R. A.

LACHMAN, A.

Spreckels

BERGH, E. M.

Stanford Univ.

MITCHELL, J. P.

STILLMAN, J. M.

COLORADO

Denver

GRAHAM, W. C.

SHAFFER, R. W.

CONNECTICUT

Bridgeport

CAREY, T. F.

Cheshire

BASSETT, WM. H.

Naugatuck

ADGATE, M.

New Haven

HOPKINS, A. T.

LUNN, C. A.

Westport

FOX, H. W.

DELAWARE

Newport

BERG, H. V.

Wilmington

ALLEN, WM. P.
 ARNOLD, C. E.
 CHAMBERS, A. D.
 CLOUGH, R. G.
 CRANE, J. E.
 KAISER, P. C.
 QUAYLE, W. O.
 REESE, C. L.
 ZEISBERG, F. C.

DISTRICT OF COLUMBIA

Washington

BAIN, J. W.
 CUSHMAN, A. S.

HOPKINS, N. M.
 SMITH, H. E.

GEORGIA

Atlanta

FAIRLIE, A. M.

Savannah

GIBSON, F. I.

ILLINOIS

Belleville

MALINOVSKY, A.

East St. Louis

BROOKS, P. C.

Chicago

ALEXANDER, D. B. W.
 BUCHANAN, E. F.
 CONVERSE, W. A.
 DE BEERS, F. M.
 FLICK, D. M.
 GUDEMAN, EDWARD
 HAGEDORN, C.
 HOSKINS, WM.
 LIHME, C. B.
 LOWENSTEIN, A.
 MARCEAU, E. T.
 MCCORMACK, H.
 PICKARD, GLENN H.
 RICHARDSON, WM. D.
 SADTLER, P. B.
 WURSTER, O. H.

Evanston

BRAGG, E. B.

La Grange

AYER, A. W.

Oak Park

DAVIDSON, G. M.
 WILLARD, F. W.

Pekin

GRAY, C. W.

Peoria

SCHUELER, J. L.

Robinson

GOMORY, W. L.

Urbana

BARTOW, ED.
 PARR, S. W.

Chicago Heights

ANDREWS, L. W.

INDIANA

Indianapolis

ELDRED, F. R.

JORDAN, H. E.

IOWA

Charles City

HANSEN, L. M.

LOUISIANA

Baton Rouge

COATES, C. E.

New Orleans

BECNEL, L. A.

WILLIAMSON, C. S.

MARYLAND

Baltimore

DAILEY, J. G.

MEADE, R. K.

MILLER, E. B.

Chevy Chase

MINOR, J. C.

THOMAS, J. B.

Cumberland

COHEN, H. B.

Curtis Bay

MARSHALL, A. E.

MASSACHUSETTS

Boston

CAMPBELL, C. L.

HOWARD, HENRY

WESTON, R. S.

Leonister

JOYCE, C. M.

Lowell

OLNEY, L. A.

Cambridge

KALMUS, H. T.

LITTLE, A. D.

SHARPLES, S. P.

Newton Centre

WALKER, G. E.

Everett

STANTIAL, FRANK G.

Wakefield

GARDNER, A. L.

Fall River

AUSTIN, H.

Worcester

WILSON, E. D.

MICHIGAN

Ann Arbor

BADGER, W. L.

BRAGG, C. T.

CONNER, A. B.

Arm Arbor

WHITE, A. H.

DURFEE, E.

KIMMEL, H. R.

PLUMB, R. A.

Detroit

BAIRD, WM. H.

SMITH, M. B.

WARE, E.

MICHIGAN—*Continued**Fenton*

SIMMONS, W. H.

*Midland*DOW, H. H.
GRISWOLD, T.
WHITE, A. C.*Wyandotte*

TUCKER, E.

MISSOURI

Joplin

SCHAEFFER, J. A.

Kansas City

LUNDTEIGEN, A.

*St. Louis*BEBIE, J.
BOYLSTON, A. C.*St. Louis (cont.)*FRERICHS, F. W.
LARKIN, E. H.
MALLINCKRODT, E.
MOORE, P. A.
NEWMAN, A. B.
VEILLON, A. A. L.
WOOD, B. G.

NEBRASKA

Omaha

BARR, WM. M.

CROWLEY, C. F.

NEW HAMPSHIRE

Berlin

MOORE, H. K.

NEW JERSEY

Arlington

CALVERT, R. P.

Bayonne

PARKER, T. J.

*Bound Brook*BICKNELL, R. S.
HEMINGWAY, F.*Chrome*

PUCKHABER, G. C.

*East Orange*BINNALL, F. C.
MATOS, L. J.
MYERS, R. E.*Elizabeth*BOOTH, L. M.
GRAY, THOS. T.*Garfield*

GESELL, W. H.

NEW JERSEY—Continued

Gloucester City

DODGE, C. A.
HOLLAND, WM. R.
MINER, H. S.

Jamesburg

FOERSTERLING, H.

Jersey City

HELLER, H.
ITTNER, M. H.
SIMPSON, ED. H.

Maurer

MILLER, J. S.

Millville

BARTON, G. E.

Montclair

ELLIS, CARLETON
WESSON, DAVID

Newark

PROCHAZKA, GEO. A.
PROCHAZKA, G. A., JR.

New Brunswick

KILMER, F. B.
PHILIPP, H.

Passaic

CAREY, T. F.

Paterson

LAMAR, W. R.

Perth Amboy

ROESSLER, F.

Phillipsburg

BAKER, J. T.

Plainfield

TAYLOR, D. W.

Rahway

KIPPENBERG, H.

Rutherford

SCHROEDER, C. M. EDW.

Woodbridge

DILL, COLBY

NEW YORK

Beechurst, L. I.

LANDIS, W. S.

Hastings-on-Hudson

ZINSSER, F. G.

New York City

ACHESON, E. G.
ADAMSON, G. P.
ALEXANDER, JEROME
ALLEN, C. D.
ANSBACHER, L. A.
BAINBRIDGE, W. C.
BASKERVILLE, CHAS.
BAUER, G. C.
BRIERLEY, J. R.
CHUTE, H. O.
DAVIS, C. E.

DE CEW, J. A.
DODGE, FRANK E.
DORR, J. V. N.
DOW, A. W.
ECKELMANN, L. E.
FOWLER, T. V.
GAYLEY, JAS.
GOMORY, WM. L.
GROSVENOR, WM. M.
HAHLWEG, G. P.
HERRESHOFF, J. B. F.
JAMES, G. B.
JAYNE, D. W.
JOHNSTON, W. S.
JONES, A. B.
KAUFMANN, H. M.
KEYES, D. B.

NEW YORK—*Continued*

KINGSBURY, P. C.	WHITAKER, M. C.
KLOTZ, J. R. M.	WHITCOMB, L. R.
LANGMUIR, A. C.	WIECHMANN, F. G.
LESLIE, E. H.	WOOD, F. J.
LOVE, ED. G.	ZWINGENBERGER, O. K.
LUNT, G. P.	
MARSH, C. W.	<i>Niagara Falls</i>
McILHINEY, P. C.	FULLER, G. P.
MATTHEWS, J. M.	HOOKE, A. H.
McKEE, R. H.	KELLOGG, H. W.
McKENNA, C. F.	LIDBURY, F. A.
METZ, G. P.	TONE, F. J.
METZGER, F. J.	
MOSCOWITZ, A.	<i>Rochester</i>
MURRILL, P. I.	ZIMMERLI, W. F.
OLSEN, J. C.	
PUCKHABER, G. C.	<i>Schenectady</i>
RAPELJE, W. S.	BURKLEY, C. J.
SIDEBOTTOM, H.	HULL, F. A.
SIMON, CLARENCE K.	
SMITH, F. P.	<i>Syracuse</i>
STAATS, E. W.	BOOTH, WM. M.
SUMMERS, F. P.	JONES, L. C.
TAKAMINE, J.	PORTER, J. EDW.
THOMPSON, G. W.	SUNDSTROM, C.
TOCH, M.	
TUNISON, B. R.	<i>Troy</i>
TYLER, S. L.	MASON, WM. P.
WAGNER, T. B.	
WEISS, J. M.	<i>Wantagh, L. I.</i>
WHEELER, T. L.	SEAMAN, E. H.
	<i>Yonkers</i>
	BAEKELAND, L. H.

NOVA SCOTIA

Bear River

McINTYRE, A. G.

OHIO

Akron

FRITZ, R. D.
GALT, H. A.
OENSLAGER, G.
SILVER, J. R.

Barberton

GAGE, R. M.

Cincinnati

BRECKLEY, A. M.
GUILLAUME, A.
HILTON, R. W.

OHIO—Continued

Cleveland

CLARK, WM. M.
 CLYMER, W. R.
 CROSS, E. O.
 DORSEY, F. M.
 DUNBAR, J. H.
 GRASSELLI, T. S.
 GRAVES, W. G.
 HOLTON, E. C.
 KRAUSE, A. H.
 LEE, F. H.
 LIHME, I. P.
 SMITH, A. W.

Columbus

THIELE, L. A.
 WITHROW, J. R.

Dayton

THICKENS, J. H.

Elyria

BURNS, DEANE
 POSTE, E. P.
 STARK, A. L.

Lakewood

CHANEX, N. K.
 DREFAHL, L. C.

Mansfield

CORSE, W. M.

Rittman

LAIB, N.

Toledo

GAGE, R. M.

OKLAHOMA

Ada

BAYLEES, O. A.

CHANDLER, A. R.

OREGON

Portland

LAZELL, E. W.

PENNSYLVANIA

Beaver Falls

PETERSON, C. A.
 SCHOLES, S. R.

Bristol

CARNELL, W. C.
 HOLLANDER, C. S.

Chester

COMEY, A. M.

Easton

ANDERSON, L.
 HART, EDW.
 SHIMER, P. W.

Erie

BEHREND, O.

Hanover

DELANEY, C. R.

New Kensington

BELL, A. D.
 HOFFMAN, WM. E.

Palmerton

CROLL, P. R.

Philadelphia

BASSETT, H. P.
 BOWER, WM. H.
 CARNELL, WM. C.
 DANNENBAUM, H.
 GIBBS, A. E.
 GLOVER, H. L.

PENNSYLVANIA—*Continued**Philadelphia (cont.)*

GROVE, S. F.
 HESS, J. R.
 HILL, J. B.
 LAWRENCE, J. C.
 MILLER, S. P.
 MURPHY, W. B.
 PETERKIN, ALBERT G.
 RHODES, F. H.
 ROSENGARTEN, G. D.
 SADTLER, S. P.
 SADTLER, S. S.
 SCHANCHE, H. G.
 WEEKS, CHAS. A.

Pittsburg

BACON, R. F.
 CAMP, J. M.

JAMES, J. H.
 JONES, A.
 MEYERS, H. H.
 PALMER, C. S.
 RITTMAN, W. F.

Ridley Park

LE MAISTRE, F. J.

Sinnamahoning

GRAY, CHAS. W.

Scranton

EUSTON, EDWIN

S. Bethlehem

RICHARDS, J. W.

RHODE ISLAND

Newport

DAVOLL, D.

Providence

FISKE, A. H.
 HEBDEN, J. C.
 RUSSELL, W. M.

TENNESSEE

Kingsport

FRITZ, H. E.

FRENCH, EDW. H.

TEXAS

Port Arthur

McAFEE, A. McD.

VIRGINIA

Damascus

CRIST, JOHN L.

Marion

TEAS, WM. H.

WASHINGTON

Millwood

MACNAUGHTON, W. G.

Seattle

NEWHALL, CHAS. A.

WISCONSIN

Appleton

WHEELER, FRANK G.

Port Edwards

MACNAUGHTON, WM. G.

Milwaukee

KREMER, W. R.

PRENTISS, GEO. N.

Washburn

BEERS, FRANK T.

FOREIGN

AUSTRALIA

Melbourne

RIGG, GILBERT

BRITISH COLUMBIA

Vancouver

THOMSON, H. N.

CANADA

Belleville

ALLEN, L. E.

Ottawa

HAANEL, B. F.

HAANEL, EUGENE

LE SUEUR, E. A.

Exchaw

BECK, ARTHUR G.

Windsor

VORCE, L. D.

Montreal

CAMPBELL, WM. B.

Westmount

MONK, R. H.

NOVA SCOTIA

Bear River

MCINTYRE, A. G.

CUBA

Cardenas

MEADE, GEO. P.

Cienfuegos

LE BLANC, E. M.

SPAIN

Carrill

LESSNER, CHAS.

CONSTITUTION

ARTICLE I.

NAME.

This organization shall be termed,

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

ARTICLE II.

OBJECTS.

The objects of this organization shall be:

To advance the cause of applied chemical science.

To give the profession of Chemical Engineers such standing before the community as will justify its recognition by Municipal, State, and National authorities in public works.

To raise the professional standard among Chemical Engineers, discouraging and prohibiting unprofessional conduct.

To coöperate with educational institutions for the improvement of the education of the men who are to enter this profession.

To encourage original work in chemical technology.

To promote pleasant acquaintance and social and professional intercourse among its members.

To publish and distribute such papers as shall add to classified knowledge in chemical engineering and shall increase industrial activity.

ARTICLE III

MEMBERSHIP

SECTION 1. (*Qualifications for Membership.*) Membership shall consist of two grades: Active and Junior.

ACTIVE MEMBERSHIP shall require the following preparation and training:

All candidates must be not less than 30 years of age and must be proficient in chemistry and in some branch of engineering as applied to chemical problems, and must at the time of election be engaged actively in work involving the application of chemical principles to the arts. All candidates for admission to this Institute are expected to have *expert knowledge of at least one branch of applied chemistry*, and must fulfill one of the following requirements:

1. Candidates who hold no degree from an approved university or technical school must have had ten years' experience in chemical technology; five being in responsible charge of operations requiring the elaboration of raw materials, the design of machinery involving chemical processes, or the application of chemistry to industry.

2. Candidates who hold the degree of A. B. (Bachelor of Arts) from an approved university or technical school offering a four-year course must have had at least eight years of practical experience as outlined under No. 1.

3. Candidates who hold the degree of Ch. E. (Chemical Engineer), B. S. (Bachelor of Science), in Chemistry or Chemical Engineering, or E. E. (Electrical Engineer), C. E. (Civil Engineer), or M. E. (Mechanical Engineer), or equivalent degrees from an approved university or technical school offering at least a four-year course, must have had at least five years' practical experience as outlined under No. 1.

4. For candidates who in addition hold the degree of Ph. D. (Doctor of Philosophy) or Sc. D. (Doctor of Science) in Chemistry, the number of years required to earn the higher degree may be deducted from the number of years of experience required.

JUNIOR MEMBERSHIP shall require the following preparation and training:

All candidates must be not less than 23 years of age and must be engaged, at the time of election, in some branch of applied chemistry and must fulfill one of the following requirements:

1. Hold the degree of Ch.E. (Chemical Engineer), B.S. (Bachelor of Science) in Chemistry or Chemical Engineering, E.E. (Electrical Engineer), C.E. (Civil Engineer), M.E. (Mechanical Engineer), or equivalent degree from an approved university or technical school offering at least a four years' course.

2. Have had five years' experience in Applied Chemistry.

Junior Members shall have all privileges of the Institute excepting those of voting, holding office, and wearing the emblem or badge of Active Membership. A suitable emblem or badge of Junior Membership as adopted by the Institute may be worn by the Junior Members. When qualified, a Junior Member may apply for Active Membership, but must do so before reaching the age of 35, otherwise his membership shall expire.

Section 2. (*Applications.*) All applications for membership must be made to the Secretary in writing, and shall embody a concise

statement with the dates of the candidate's professional training and experience, and shall be in a form and in such detail as may be prescribed by the Membership Committee. The applicant for Active Membership shall give the names of at least five members to whom he is personally known. The applicant for Junior Membership shall give the names of at least five persons to whom he is personally known, two of whom shall preferably be members of the Institute. Each of these shall be requested by the Secretary to certify to the training, experience, professional attainment, and standing of the applicant. On receiving a favorable report from at least three of these references, the applicant shall be eligible to recommendation by the Membership Committee.

Section 3. (*Election of Members.*) At stated periods the Secretary shall mail to the members a ballot containing a list of all applicants who have been recommended by the Membership Committee. This list shall contain a detailed statement of each applicant's career and the names of the members who have vouched for him. All ballots shall be returned to the Secretary not later than three weeks after the date of issue. The ballots shall be canvassed by the Membership Committee, who shall report to the Council, who shall then declare **each applicant elected for whom at least ninety-five per cent. of all ballots cast are in the affirmative.** Provided, however, that **any** member voting in the negative may address a confidential letter to the Council, stating his objections to the candidate with evidence for the charges made. If the Council upon investigation considers such objections valid, they may declare an election void. A rejected candidate may make application again any time after one year. Persons elected to membership shall be notified at once by the Secretary. They must then subscribe to the rules of the Institute.

Section 4. (*Honorary Members.*) As the result of unusual ability and public recognition on the part of the industrial world, a person may, upon nomination of the Council and a vote of the Society at large, be made an Honorary Member, but at no time shall this number exceed five.

Section 5. (*Expulsions.*) For abuse or misuse of the privileges of the Institute or conduct unbecoming a member in the opinion of the Council, a two-thirds vote of the Council may expel any member of the Institute.

Section 6. (*Dues.*) The entrance fee for Active Members shall be \$15.00; Junior Members shall pay no entrance fee; Annual dues

for active members \$15.00, for Junior Members \$10.00. Junior Members, on becoming Active Members, shall pay an entrance fee of \$15.00 less \$1.00 per year for each year of their membership as Junior Members. Provided, however, that no entrance fee shall be exacted until the membership shall reach 200.

Any member may anticipate his dues for life by paying in advance such a sum as would be demanded by any reputable insurance association to yield an annuity equal to the annual dues from the time of the agreement until death. Upon resignation, or expulsion, all money so provided is to become the property of the Institute. Any person joining the Institute after the middle of the fiscal year is required to pay one-half of the dues only for that year. Any person in arrears for three months shall be notified by the Secretary. For non-payment at the expiration of one-half year, a member forfeits the right to vote or to receive the notices of the Association until dues are paid in full. Any member one year or more in arrears of dues may, on vote of the Council, be dropped from the Institute. All members are considered as such unless actual resignations are formally presented and accepted with the full payment of dues. On account of extenuating circumstances, dues may be remitted to any member by a two-thirds vote of the Council.

ARTICLE IV.

OFFICERS.

Section 1. The officers of this Society shall be a President, three Vice-Presidents, a Secretary, a Treasurer, an Auditor, and nine Directors. The officers shall be elected at the annual meeting. The President shall serve one year, the Vice-Presidents for three years each, and the Directors for three years each. The Secretary, Treasurer, and Auditor shall be elected for terms of one year each. At the first annual meeting one Vice-President shall be chosen for one year, one for two years, and one for three years. Three Directors shall be chosen for one year, three for two years, and three for three years. Thereafter, officers shall be chosen annually to serve full terms. The President, Ex-Presidents for the two years succeeding the expiration of their term of office as President, Vice-Presidents, Secretary, Treasurer, and Directors shall constitute the Council of the Institute. Directors cannot be re-elected within the current twelve months from the expiration of term. The President shall be eligible for election for two succeeding years. If a President is re-

elected, the term of each Vice-President shall be automatically extended for one year. The duties of office begin immediately after election and notification. An acceptance of office must be in writing addressed to the Secretary. Vacancies occurring in any office shall be filled by a majority vote of the Council for the unexpired term. The duties of all officers shall be such as usually pertain to their offices or may be delegated to them by the Council or the Institute.

Section 2. (*Election of Officers.*) After the election at which this Constitution is adopted, the election of officers shall be by letter ballot. The Secretary, at least eight (8) weeks prior to each annual meeting, shall send to every member of the Institute a blank nominating ballot upon which the member may make nominations for the officers and Directors to be elected at the coming annual meeting. The nominating ballot is then to be properly signed and transmitted to the Secretary not later than five (5) weeks prior to the annual meeting. It shall then become the duty of the Secretary to prepare and issue an official ballot upon which shall appear the names of all nominations for office or for Directors which shall have appeared upon at least ten (10) nominating ballots. The official ballots shall be mailed not later than three (3) weeks prior to the annual meeting, one to each member, who shall properly signify on it his choice for the various offices and Directors, and transmit it to the Secretary. At the annual meeting the President shall appoint tellers to whom the Secretary shall deliver all the ballots received by him unopened, and who shall count and announce the vote.

ARTICLE V

COUNCIL

The Council shall have supervision and care of all property of the organization, and shall conduct its affairs according to the Constitution and By-Laws. At each annual meeting it shall present a statement of its proceedings during the year. Eight members of the Council called together by notice from the Secretary shall constitute a quorum, provided, however, that three members may be represented by proxy.

ARTICLE VI.

STANDING COMMITTEES.

The Council shall appoint the following committees:

1. FINANCE.
2. COMMITTEE ON MEETINGS.
3. PUBLICATIONS.

4. MEMBERSHIP.

5. LIBRARY.

6. HOUSE COMMITTEE.

FINANCE COMMITTEE.

The Finance Committee shall have charge of the financial affairs of the Institute. This committee must prepare the budget and approve all expenditures. The Chairman of the Committee may be the Auditor of the Institute.

MEMBERSHIP COMMITTEE.

The Membership Committee shall be constituted of fifteen members, ten of whom may vote by proxy at any meeting. To the Membership Committee all applications for membership shall be referred. It is the duty of this committee to see that no person is admitted to the organization who is not qualified.

COMMITTEE ON MEETINGS.

This committee shall have charge of all meetings of the organization and shall fix dates and places of meeting.

COMMITTEE ON PUBLICATIONS.

This committee shall look after the papers presented to the Institute. If considered expedient, any or all of these papers may be published and distributed to members.

LIBRARY COMMITTEE.

This committee shall have charge of all permanent records, books, papers, pamphlets, etc., and shall obtain and place on file a complete record of all patent literature in reference to chemical engineering.

HOUSE COMMITTEE.

This committee shall look after the social affairs of the Institute, fixing the time and place of entertainments.

ARTICLE VII.

MEETINGS.

The annual meeting of the Association shall be held in December, the exact date to be fixed by the Council.

This Institute shall be governed by its Constitution in conformity with the laws of the United States. All questions shall be decided by majority of votes cast. The Institute shall not be held

responsible for opinions expressed in papers. The name or use of the Institute shall not be tolerated for any commercial purpose.

Upon the adoption of this Constitution officers shall be elected immediately to hold office until the election and installation of their successors.

ARTICLE VIII.

AMENDMENTS TO THE CONSTITUTION.

Any member may propose an amendment by addressing the Secretary. At the first regular meeting thereafter the subject shall be discussed, and if worthy, notice to vote on same shall be posted until the next regular meeting, and written copy of the notice shall be sent to each member. The proposed amendment shall then be discussed in open meeting and can be passed by two-thirds vote of all members of the Institute as the result of letter ballot.

BY-LAWS

ORDER OF BUSINESS.

REGULAR MEETING.

- Reading of minutes of last stated meeting.
- Miscellaneous announcements.
- Reading of papers, discussion, and communications.
- Adjournment.

ANNUAL MEETING.

- Reading of minutes of last stated meeting.
- Miscellaneous announcements.
- Stated business.
- Annual reports.
- Election of officers.
- Address of retiring President, etc.
- Adjournment.

In all questions requiring parliamentary ruling not provided for by the Rules of the Institute, "Robert's Rules of Order" shall be the governing authority.

CODE OF ETHICS

ARTICLE I.

PURPOSE OF THE CODE:

To define the rules of professional conduct and ethics for the members of the Institute.

ARTICLE II.

THE INSTITUTE EXPECTS OF ITS MEMBERS:

1st. That in all their relations, they shall be guided by the highest principles of honor.

2d. The upholding before the public at all times of the dignity of the chemical profession generally and the reputation of the Institute, protecting its members from misrepresentation.

3d. Personal helpfulness and fraternity between its members and toward the profession generally.

4th. The avoidance and discouragement of sensationalism, exaggeration and unwarranted statements. In making the first publication concerning inventions or other chemical advances, they should be made through chemical societies and technical publications.

5th. The refusal to undertake for compensation work which they believe will be unprofitable to clients without first advising said clients as to the improbability of successful results.

6th. The upholding of the principle that unreasonably low charges for professional work tend toward inferior and unreliable

work, especially if such charges are set at a low figure for advertising purposes.

7th. The refusal to lend their names to any questionable enterprise.

8th. Conservatism in all estimates, reports, testimony, etc., especially in connection with the promotion of business enterprises.

9th. That they shall not engage in any occupation which is obviously contrary to law or public welfare.

10th. When a chemical engineer undertakes for others work in connection with which he may make improvements, inventions, plans, designs or other records, he shall preferably enter into a written agreement regarding their ownership. In a case where an agreement is not made or does not cover a point at issue, the following rules shall apply:

a—If a chemical engineer uses information which is not common knowledge or public property, but which he obtains from a client or employer, any results in the form of plans, designs or other records shall not be regarded as his property, but the property of his client or employer.

b—If a chemical engineer uses only his own knowledge or information or data, which by prior publication or otherwise are public property, and obtains no chemical engineering data from a client or employer except performance specifications or routine information, then the results in the form of inventions, plans, designs or other records should be regarded as the property of the engineer and the client or employer should be entitled to their use only in the case for which the engineer was retained.

c—All work and results accomplished by the chemical engineer in the form of inventions, plans, designs or other records, or outside of the field for which a client or employer has retained him, should be regarded as the chemical engineer's property.

d—When a chemical engineer participates in the building of apparatus from designs supplied him by a client, the designs remain the property of the client and should not be duplicated by the engineer nor anyone representing him for others without express permission.

e—Chemical engineering data or information which a chemical engineer obtains from his client or employer or which he

creates as a result of such information must be considered confidential by the engineer; and while he is justified in using such data or information in his own practice as forming part of his professional experience, its publication without express permission is improper.

f—Designs, data, records and notes made by an employee and referring to his employer's work, should be regarded as his employer's property.

g—A client does not acquire any exclusive right to plans or apparatus made or constructed by a consulting chemical engineer except for the specific case for which they were made.

11th. A chemical engineer cannot honorably accept compensation, financial or otherwise, from more than one interested party, without the consent of all parties; and whether consulting, designing, installing or operating, must not accept compensation directly or indirectly from parties dealing with his client or employer.

When called upon to decide on the use of inventions, apparatus, processes, etc., in which he has a financial interest, he should make his status in the matter clearly understood before engagement.

12th. The chemical engineer should endeavor at all times to give credit for work to those who, so far as his knowledge goes, are the real authors of such work.

13th. Undignified, sensational or misleading advertising is not permitted.

14th. Contracts made by chemical engineers should be subject to the Code of Ethics unless otherwise specified.

ARTICLE III.

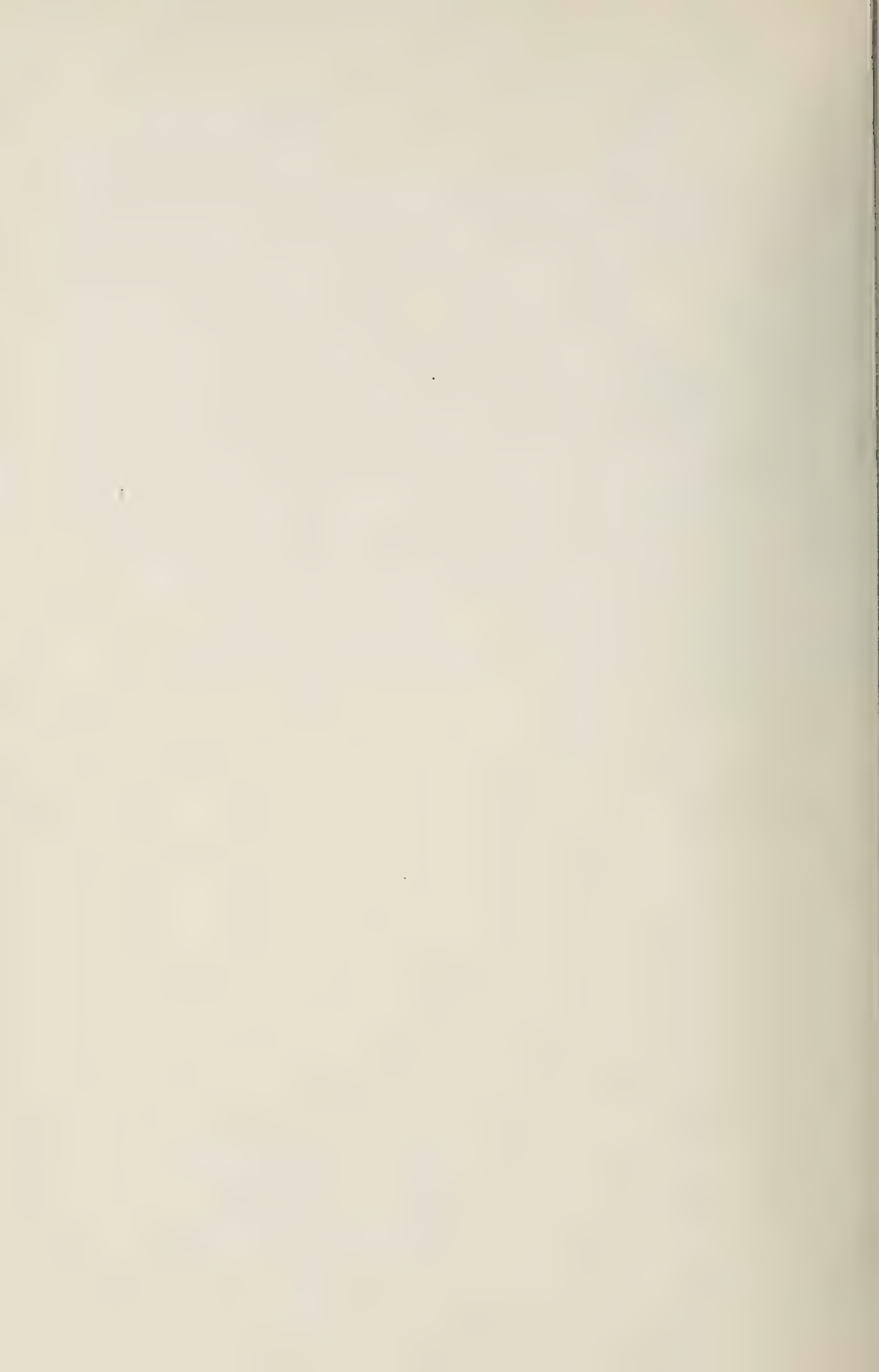
For the administration of this Code of Ethics, a Committee on Ethics shall be appointed by the president holding office at the time of the adoption of this Code with the approval of the Council, to consist of five members; one appointed for five years, another for four years, another for three years, another for two years, another for one year, and thereafter, the president then holding office shall appoint one member annually to serve for five years and also fill such vacancies as may occur for an unexpired term. All of these members shall be over forty years of age. The Committee shall elect its own chairman. The Committee on Ethics shall investigate all complaints submitted to them bearing upon the professional con-

duct of any member, and after a fair opportunity to be heard has been given to the member involved, shall report its findings to the Council, whose action shall be final.

ARTICLE IV.

AMENDMENTS.

Additions to or modifications of this Code may be made according to Article VIII of the Constitution.



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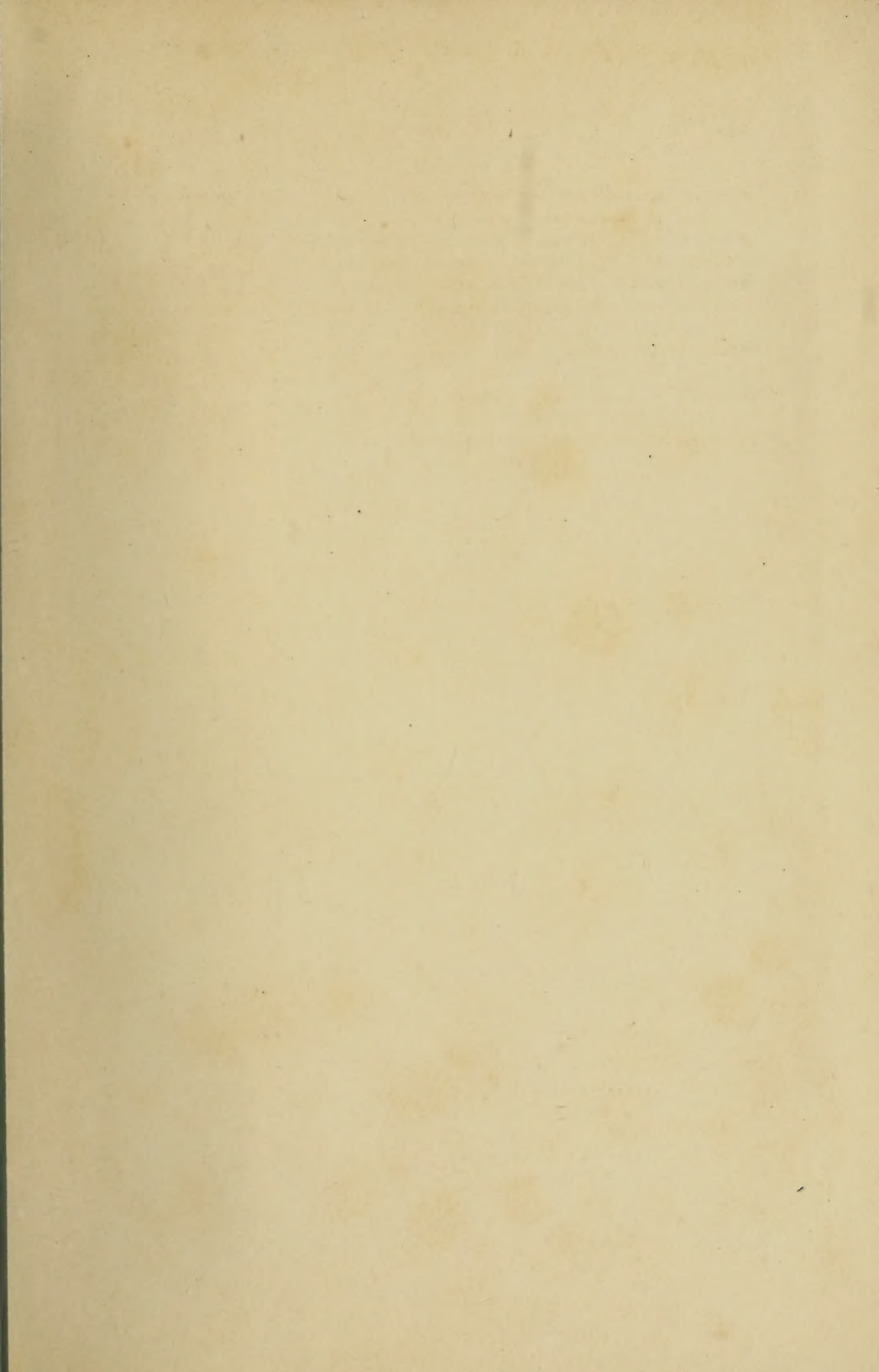
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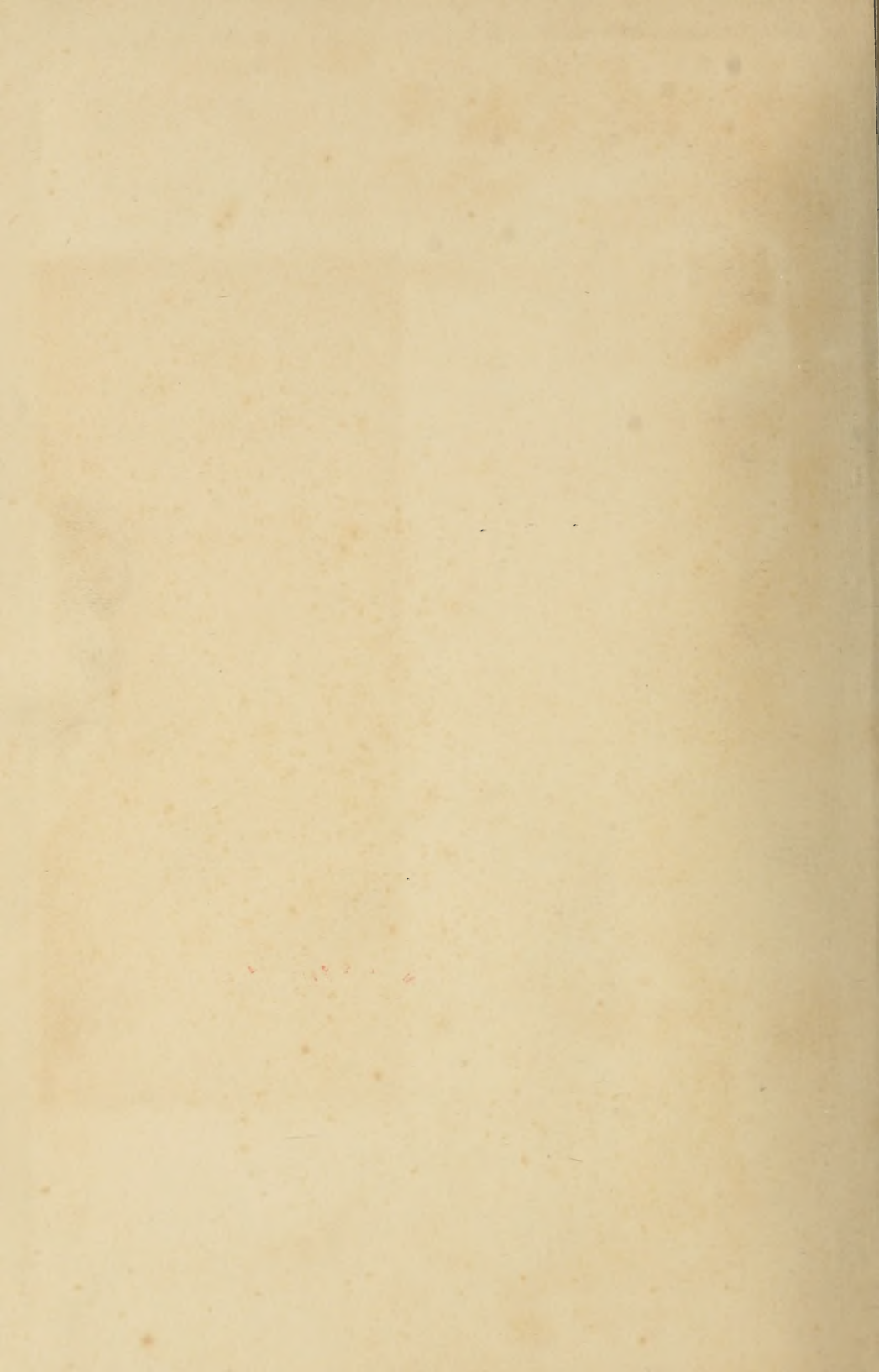
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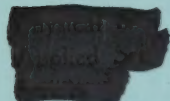
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